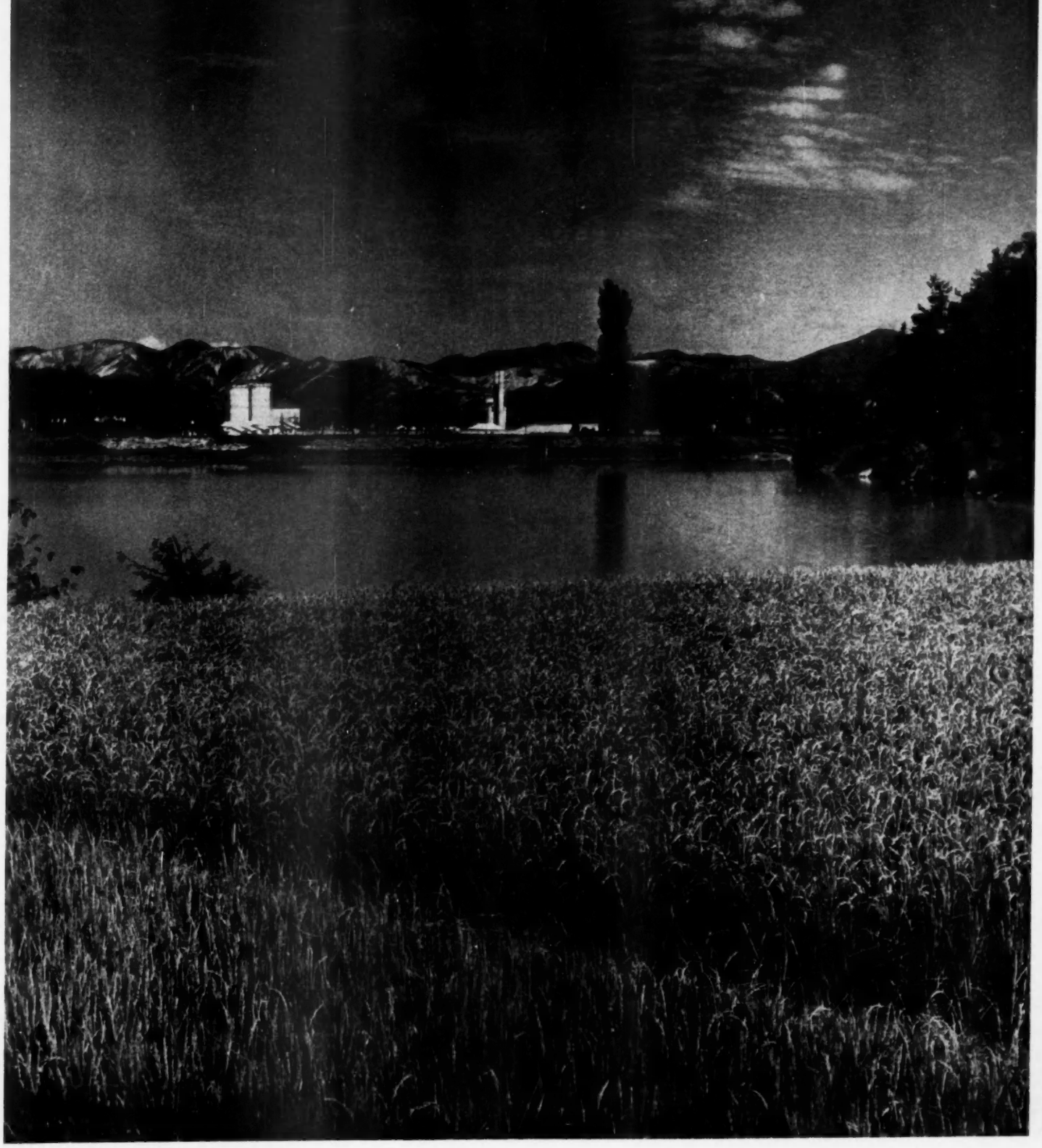
ENGINEERING 4-1-57

ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 - - TELEPHONE: TEMPLE BAR 3663

Vol. 183 No. 4739 *LONDON, FRIDAY, JANUARY 4, 1957* PRICE 2s.



VALLEY WITH A FUTURE

JANUARY 4, 1957 VOL. 183 PAGES 1-32

ENGINEERING

An Illustrated Weekly Journal

Vol. 183 No. 4739 JANUARY 4, 1957

Leading Article

Plant Plans 1

Plain Words 2

Weekly Survey 7

Principal Articles

Bearings Since the Stone Age: A Short History of Their Development 2
Engineering Centenaries of 1957 6
The Engineering Outlook—1: Business in 1957 9
Storing Fuel Oil: Heating Requirements and Fire Risks with Heavy Grades 12
An Iron Foundry Enlarged: Wide Range of Castings for Machine Tools 13
Exhaust Pulse Energy: Utilisation of Diesel Engine Gases in Turbines 14
Reducing Engine Noise at Ashford Common Pumping Station: Enclosures for Diesel-Generator Sets 16
Stress Raising Effects of Holes in Web Plates: Design Chart Plotted 18
High-Intensity Combustion: Limitations of Existing Chambers 20
Holme Moss Very-High-Frequency Station: Frequency Modulation Extended to Wide Area 21
Exhaust Turbo-Chargers for High Speed Diesels: C.A.V. Developments 22
Pipe Coupling 22
Marketing: On World Tours 24
Railway Electrification Continued 25
Flameproof Lamp 27
Power Assisted Steering 27
Atomic Review: East and West 28

Letters to the Editor

Preserving Cornish Engines 5
F. W. Lanchester's Biography 5

Book Reviews

The Theory and Technique of Ship Design 23
Industrial Engineering Handbook 23

Trade Publications 23

Notes

Off-Shore Boring 12
New Premises of the I.Chem.E. 12
North of Scotland Power 12
Information Centre for Applied Materials 13
Marine Diesel Engine 13
Checking Secondary Light Standards 17
Carrier Telephony for Eire 17
Tachometer Using Polyphase Alternating Current 19
Plastic Lagging 22
Electrical Controls on the " John Biscoe " 24

Notices of Meetings 26

In Parliament 31

The Human Element 32

★ ★ ★

Published every Friday by Engineering Limited, 35 & 36 *Bedford Street, Strand, London, W.C.*2
TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663

★ ★ ★

Subscription Rates for 12 *months, Inland and Abroad* £5 10*s.*, *Canada* £5 5*s. Subscriptions for periods of less than* 12 *months are based on the price of a single copy including* **postage** (2*s.* 3*d.*)

PLANT PLANS

THE future for British engineering was deftly sketched last week by the Board of Trade from information supplied by a sample of some 600 firms concerning their investment plans for the current year. There is no doubt as to the sombre message of the figures: the rate of increase in capital expenditure by manufacturing industry is falling, and may be transformed into an actual decrease towards the end of the year.

Taking actual expenditure first, it is to be 11 per cent. higher in the third quarter of this year than in the corresponding period last year, but increases in the second and first quarter had been 26 and 27 per cent. respectively. Taking next the forecasts, they show that manufacturing firms providing the information are intending to spend on an average very little more this year than they had intended to spend last year. In their summer returns they expected to spend 1 per cent. less; now this has been revised to 1 per cent. more. But the returns were probably filled in before the Suez Canal was closed and certainly before the serious economic consequences of its closure were realised. There may therefore be a downward revision of capital investment plans unless the Government act quickly to counteract these influences. So far there are few signs that they are willing to do so: the reduction in the initial down payment for the hire purchase of a car from one half to one-fifth of the retail price is unlikely to do much more than counteract the effect of petrol rationing unless both are thought (as is likely) to be temporary. It is now known that the Suez Canal will not be open until the end of March at best. The full implications have yet to be worked out—they may turn out to be less crippling than first feared.

What lies behind the anticipated slowdown of the rate of investment? It could hardly be that the price of labour is too low to make the purchase of machines worthwhile. Availability of machinery could play a part, as there is little to be gained from elaborate plans which involve ordering plant and machinery on a three to five years' delivery. But we are in a period of radical change in the methods of production. Failure to invest could be very dangerous if it should become general. Already Britain is losing ground in export markets to countries whose production is rising rapidly and whose rate of investment is much higher. At the end of 1956 the level of total production in British industry was little different from what it was in mid-1955. This, clearly, is most unsatisfactory. Information published by the more progressive companies, in engineering and elsewhere, shows that output leapt forward during 1956 and that heavy capital investment also took place. The " average " stand-still implies a deplorable performance on the part of too many companies—in some cases the majority of complete industries. What should have taken place, and did not, was for the fall in home sales and the rise in total output to have been taken up by increased exports. The performance of one of the leading bicycle manufacturing groups in this respect is a very good illustration of what should have taken place in industry to make the Government's deflationary policy a success. Bicycles became hard to sell at home, the company's sales fell, but their output increased and the whole of the difference was exported at competitive prices.

The unpleasant interpretation of the Board of Trade's figures is that British companies are not taking up the challenge which the country must take up if it is to grow in strength and its people in well-being. Not to continue to expand and to modernise with the most up-to-date machinery available is suicidal for any engineering company with export markets. This is seen more clearly if the figures are examined in the full detail available. Taking expenditure on plant, machinery and vehicles, which should go on irrespective of building work, the largest by far is " chemicals and allied trades "—which include the oil industry—and the iron and steel industry. These two industrial groups expect their purchases to rise by 26 and 18 per cent. respectively in 1957 as compared with 1956. Otherwise, only two other groups envisage an increase—non-ferrous ore treatment and vehicles. Motor vehicles foresee the same amount being spent in 1957 as in 1956. It is unfortunate that the figure for shipbuilding should be hidden in the " vehicles " total, with motor vehicles, cycles and aircraft. Shipowners expect an increase of 13 per cent. in their purchases of new ships and this programme may well have been revised upwards since the Suez closure has placed a premium on large and fast tanker and other cargo tonnage.

The really shattering figure is that for " metal using, other than vehicles," which includes the bulk of the engineering industries. Expenditure on plant and machinery in this group is scheduled at 6 per cent. less than was expected in 1956, and on building work at 15 per cent. less. There again, the inclusion of electrical engineering—a rapidly expanding section—distorts the true picture in respect of the remainder of the engineering industries, which must be even more depressing.

There is every reason for British engineering to invest in the future. Enterprising concerns have proved the truth of this again

and again in the past year, and will go on doing so. To say that shortages—of labour, of materials, of plant and machinery—set a ceiling to what can be done, or that taxation takes away the means and the will to grow, or that misguided politicians (they are far from scarce) will wreck any good intentions, is merely listing the problems and obstacles. They are there to be solved or overcome.

★ ★ ★

Plain Words

The Government have clearly lost control of the motor-car industry's production prospects. Before the Suez crisis developed there were indications that the motor-car manufacturers were to be made the star performers in the Government's circus programme to reduce inflation. Sales in the home market were to be discouraged in order to force cars overseas. As ringmaster, the Chancellor of the Exchequer showed signs of both confidence and elegance in handling his chosen performers. In the event, the promised orderly performance has developed into a disorderly scramble.

It was apparent before the Suez crisis, as was patent to many outside observers, that cars could not be forced on unwilling buyers in the export markets. The Suez crisis has made the export problem all the more difficult by causing a jam at the docks. Petrol rationing has been a final blow to any hope the Government might have had that restrictions in the home market could be delayed to avoid chronic depression among car makers. The decision to cut temporarily the restrictions on initial hire-purchase payments on cars, light vans and motor-cycles from 50 to 20 per cent. is a clear indication that the future of the car industry is thought to be at stake. Although the change covers both new and second-hand cars it remains to be seen what help the cut can give to the industry during the winter, a period when sales are anyway normally poor and prices in the secondhand market are depressed, let alone the additional factor of petrol scarcity. Although the relaxation in hire-purchase terms is described as temporary it will be very surprising if the previous down payments are reintroduced. There is just a possibility, if commonsense prevails, that the clearing of the Suez Canal may coincide with the annual seasonal improvement in car sales. If this should be so the industry will receive a much-needed boost in the spring.

The only justification that there could have been for inducing a moderate recession (assuming always that the industry suffers no worse than that) would be that the labour released could be absorbed elsewhere. The alternative—that there could be a boom in export markets—sounds hardly realistic at the moment so far as the big Commonwealth markets are concerned, yet that is where the boom is required. One way and another the policy of putting a gradual and gentle curb on the national economy by jamming a sharp brake on motor-car output seems to have had its day.

BEARINGS SINCE THE STONE AGE

A SHORT HISTORY OF THEIR DEVELOPMENT

By C. St. C. Davison, M.SC., PH.D.*

When, during the war, we were anxious to bring the German war effort to a standstill, we chose as one of our principal bomber targets the town in which the German bearing industry was largely concentrated. We knew that, without bearings, the wheels of a modern state would cease to turn. In this article the author first describes how bearings were developed from primitive times up to the Eighteenth Century. He then follows them through various stages of refinement up to the present day, when owing to their wide use on vehicles and all kinds of appliances they have become essential to the smooth running of our civilisation. Previous historical articles by Dr. Davison published in ENGINEERING *have dealt with gears (February* 10, 1956, *page* 133) *and the internal-combustion engine (August* 31, 1956, *page* 258).

PALAEOLITHIC DRILLS

Drills made during the Palaeolithic Period either for producing fire or for drilling holes were fitted with bearings. One end of the drill-spindle was supported by the points of antlers or bones, which were held in a recessed part of the drill so that it was easier to operate and unlikely to burn or wear too rapidly. Drills with elementary bearings were also used by the early Egyptians, and Fig. 1 shows a hand-supported bearing on an Egyptian drill. Sometimes a piece of stone served as a bearing.

Writers have often stated that rollers acting as bearings were placed under sledges in the Seventh Century B.C. supposedly to facilitate the pulling of the sledges and the *colossi* they carried. This is a technical error, unfortunately perpetuated, which arose when bas-reliefs were discovered in 1845 depicting sledge transport at Nineveh, where the Assyrian King Sennacherib's palace was built.[1] It can be clearly seen from Fig. 2, which is a drawing made from one of the bas-reliefs, that the pieces of wood, which were incorrectly called rollers, were not placed transversely in front of and under the sledge as rollers, but in the direction of motion. A careful study of the reference given here and an examination of the bas-reliefs in the British Museum substantiate these inferences. Similarly, no records have been found to show that rollers were used for a like purpose in neighbouring Egypt.

* Assistant Keeper, Science Museum.

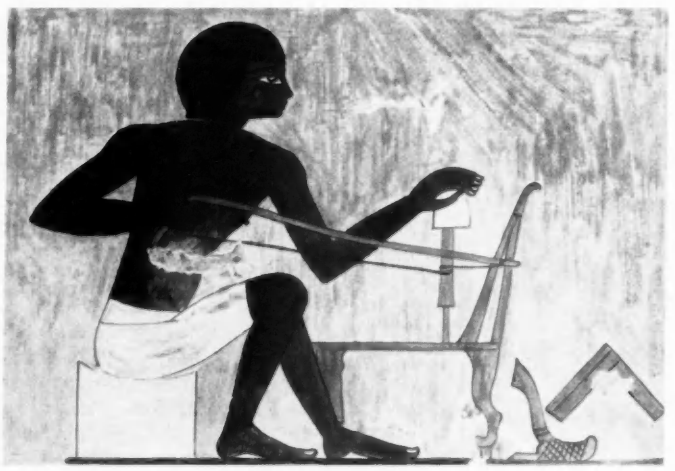


Fig. 1 Drills used by early Egyptian craftsmen were supported by simple bearings held in the hand. Long before, in Palaeolithic times, bearings had been made from antlers or bones; a bearing of this kind fitted into a recessed part of a drill spindle, so making the drill easier to use.

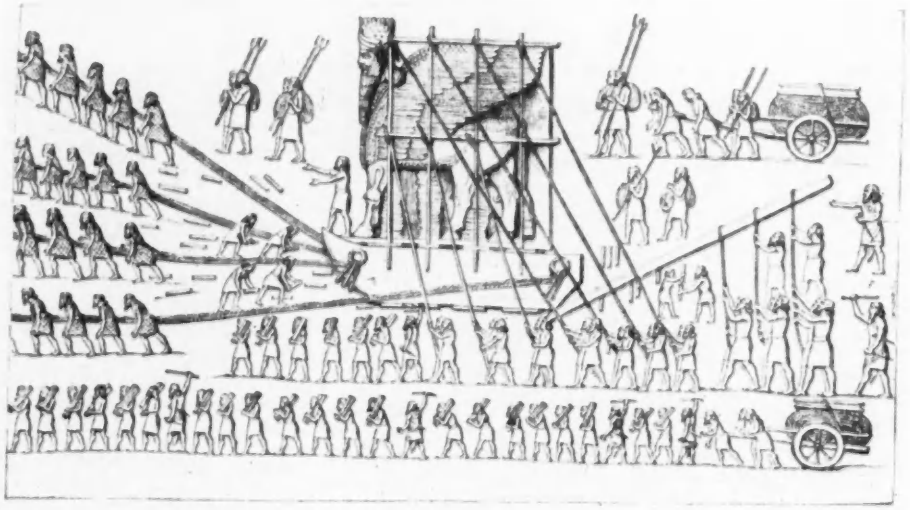


Fig. 2 It has been said that roller bearings were used under Egyptian and Assyrian sledges in the Seventh Century B.C., but this drawing reveals that the wooden "rollers" were in fact used to facilitate sliding, being placed in the direction of motion and not transversely.

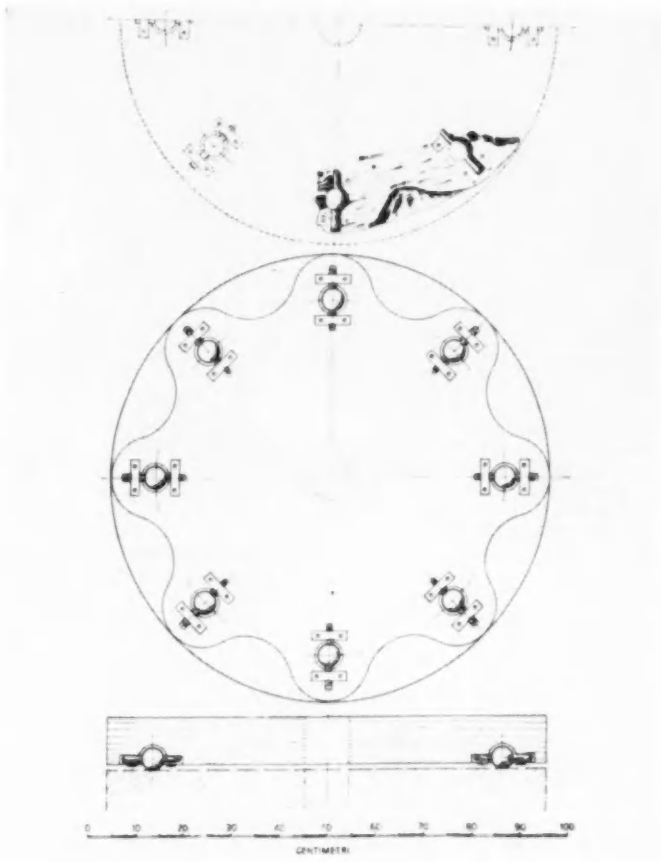


Fig. 3 (left) A bearing employing bronze balls with trunnions discovered under Lake Nemi near Rome. It is presumed to date from about 40 A.D. Top left is a reconstruction of the complete bearing.

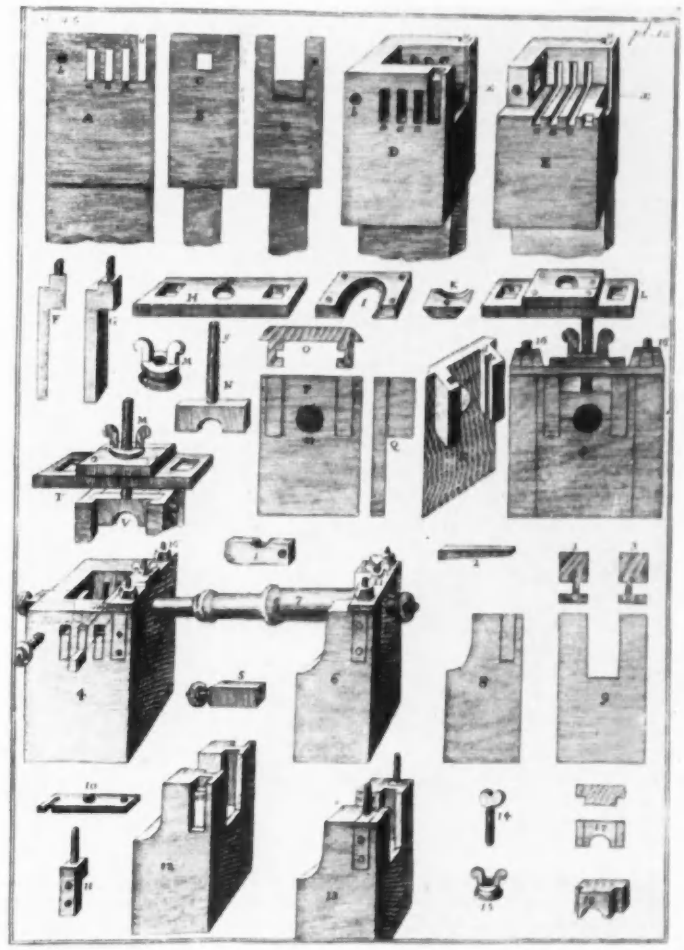


Fig. 5 (above) In 1701 Plumier published drawings of bearings which were adjustable for wear. The pillows were of zinc and made in two halves that slid into vertical grooves in a wooden body.

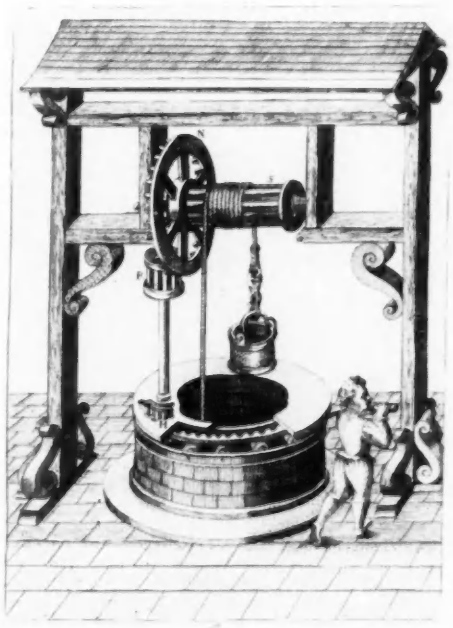


Fig. 4 Ramelli in a book of 1588 illustrated bearings in devices for raising water, though it is thought that working machines were never made to his designs.

It was possible, however, that fairly large stones were placed on tree trunks and manoeuvred with levers for several feet on a hard rock foundation, but there is no record to confirm this.

The earliest recorded roller bearing is therefore one fitted to a battering-ram during a siege of Cadiz by a Greek engineer called Diades about 330 B.C.[2] It was in the form of small rollers which ran in grooved tracks and were held in place by a kind of cage. It lay between the heavy ram and a stationary base on the ground.

Egyptian chariots had plain grease-packed bearings which were protected from sand by leather covers. Marcus Vitruvius Pollio[2] described machines, such as water-raising devices, having axles hooped with iron at their ends; these rested in wooden bearings cased with sheet-iron (*c.* 25 B.C.). He also mentioned iron-covered bearings for war vehicles. Part of a bearing of about 40 A.D. was discovered under water in Lake Nemi near Rome,[3] and as can be seen from Fig. 3, it had bronze balls with trunnions which supported a disc for carrying, perhaps, a small statue.

ROLLING AND SLIDING FRICTION

There was a retrogression in the Middle Ages and plain bearings of wood were chiefly used in machines. But iron journals and bearings were made for tower-clocks in the Fourteenth Century. New developments to suit the needs of the times were, however, brought about by military engineers and artisans after the beginning of the Fifteenth Century. Leonardo da Vinci (1452-1519) sketched roller bearings[4], and, as can be seen in Fig. 4, Ramelli[5] showed a roller bearing in a design for a water-raising machine, but the machine was probably never made. Although Aristotle (born *c.* 384 B.C.) had remarked that frictional resistance was lowest for round objects, it was believed that da Vinci was the first to investigate the forces set up by friction. He gave an account as to how he had considered objects sliding on various kinds of surfaces on inclined planes, and had made a distinction between sliding and rolling friction. He concluded that friction was less with polished and lubricated surfaces; that the friction was proportional to the pressure between the two surfaces; and he quoted a rather high coefficient of friction of one-quarter. Benvenuto Cellini, the famous Sixteenth-Century sculptor, painter, metal worker and autobiographer, was responsible for the earliest record of ball-bearings. He explained how he had finished a beautiful statue of Jupiter and after placing it upon four little wooden globes in a plinth was delighted at the ease with which the statue could be rotated.

Further developments in lathes in the Sixteenth Century had improved the art of turning and a few better-made bearings naturally followed. Generally, however, bearings were made from a simple beam in which a hole was drilled, and often the beam was slit above the hole to allow the shaft to be inserted easily[6]. The bearing-pillows were made of a hardwood like cherry. The beneficial effects of proper lubrication must have been obvious to a turner who carried out work involving considerable

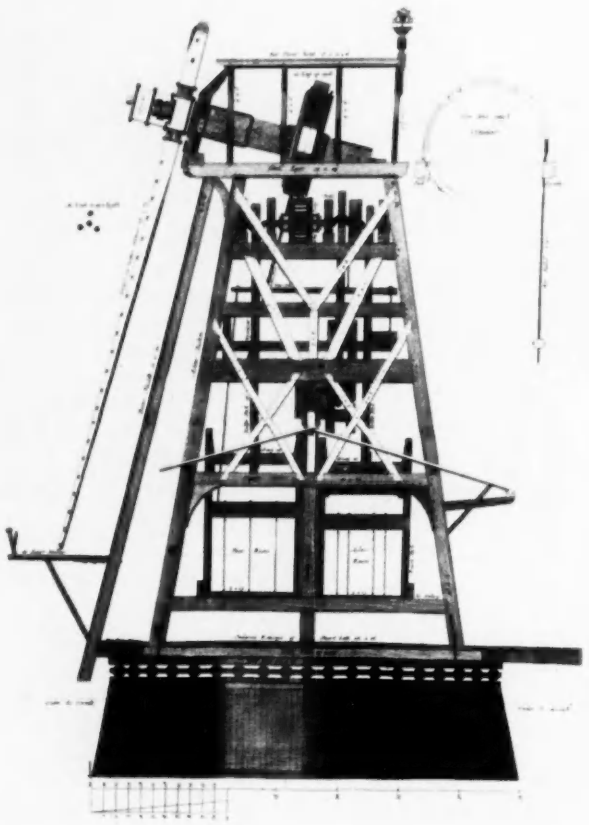


Fig. 6 Dutch millers are believed to have made the first iron roller bearings, although large pieces of wrought iron and steel were scarce and difficult to work into shape. This illustration dates from 1734.

loads and speeds on his lathe. A drawing of a bearing of that century showed an opening for a lubricant which was likely to be a vegetable oil, or a mixture of vegetable oil and tallow.

The Seventeenth Century was a time of great scientific activity and learned societies rose into prominence in Europe. The addition of the growing scientific knowledge to mechanical applications stimulated development and a new theoretical basis was laid down for practical work. More people wrote about the various subjects, and some carried out experiments which lead to greater efficiency in machine parts, and to better design. This healthy and lively interest in applied science increased the speed of approach to the industrial age. G. Amontons, the French inventor, carried out further research work on friction, and because da Vinci's work was lost he had to start afresh (1699). He discovered the relation between the angle of friction and the coefficient of friction.

BEARINGS ADJUSTABLE FOR WEAR

It was not until the Eighteenth Century however, that bearings were designed in greater detail. Lathes had become even better made and many beautiful and excellently designed objects were constructed[7]. Bearings were made adjustable for wear. Plumier made drawings of bearings like those of Fig. 5 in which the pillows were of zinc and made in two halves that slid into vertical grooves in a wooden body. An iron holding-down lid was attached by bolts fixed to the body and it supported a wing-nut on a screw which pressed the two bearing-halves closer together. The effects of friction were considered more scientifically by many investigators and useful discoveries were made. It was stated, for instance, that the relative speeds of the bearing surfaces affected frictional losses; and mechanics noted from experience that friction was greater between two bodies of the same materials than between those of different materials. Wood was still the most popular material until about the middle of the Eighteenth Century because it was cheap, and large pieces of wrought iron or steel were scarce and difficult to work into shape. The art of casting iron was not far enough advanced for engineers to make complicated parts such as axles and shafts for mills, but better methods of making cast iron and cast steel were being introduced. Henry Cort's new puddling process and his methods of making iron and steel into bars, plates, and rods, of better quality and at a lower cost, represented a great advance (Patent No. 1,420, February 14, 1784). Iron end-journals were often fitted to the extremities of wooden shafts and, as can be seen from Fig. 6, Dutch millers used iron roller bearings in windmills (1734)[8]. Brass and iron were often used in the form of sheet metal for bearing linings. There were also bearings of wrought iron or cast-iron made in halves held together by bolts. Sometimes a piece of leather was placed between the two halves so that adjustment for wear could be carried out. Alloys of copper and zinc were occasionally used for the pillows, and it was found that the frictional resistance with iron was greater than that with brass.

In 1724, J. Leupold[9] wrote about lubrication and recommended tallow or vegetable oil for rough parts, saying that: "The roughness of the surface is made less by lubrication, and the bearing surface is rolled over as if it had small balls on it." A continuously lubricated bearing was found on a lathe of 1792. Much research

Fig. 7 In 1787 John Garnett patented the type of roller bearing fitted to this apparatus, which was used by James Watt for experimental purposes.

work on friction was carried out during the second half of the century, the most important being that described by C. A. Coulomb, in his treatises of 1779 and 1781. Coulomb's name is perpetuated by the electrical unit for quantity.

BALL AND ROLLER BEARINGS

John Garnett patented, in 1787, the type of roller bearing shown in Fig. 7. The apparatus on which the bearing was fitted came from James Watt's workshop, who used it for experimental purposes. Ball-bearings were patented for the first time by Philip Vaughan in 1794; they were embodied in the axle shown in Fig. 8.

The increased interest in applied science culminated in a great many achievements which were crowned by an improved steam engine by James Watt and Matthew Boulton, built in 1784. At the same time factories with many new power-driven machines came into being. The period when these developments took place is sometimes called, perhaps wrongly, the Industrial Revolution. Great industrial advances followed in England; and in France a lead was given in theory and detailed construction[10]. Hitherto, the

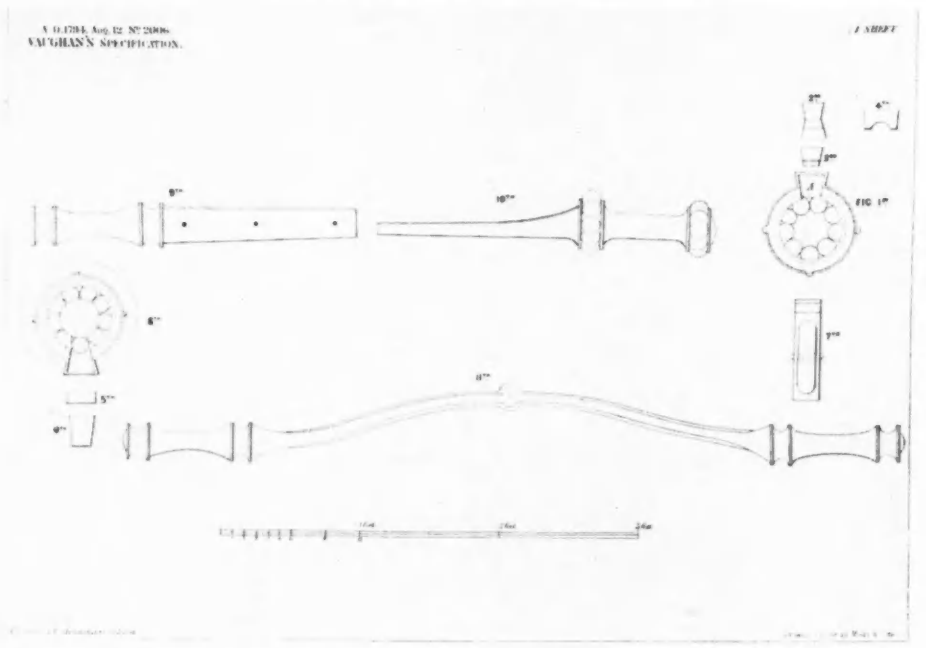


Fig. 8 Ball-bearings were patented for the first time in 1794 by Philip Vaughan, who designed an axle making use of them.

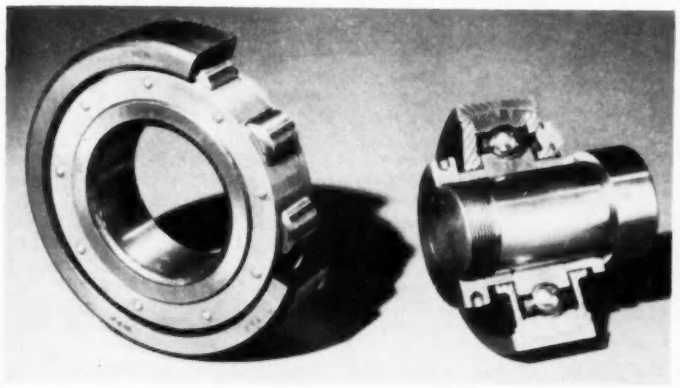


Fig. 9 Two Twentieth Century bearings: on the left is a roller bearing and on the right a sectioned self-aligning ball journal bearing of 1925.

perspective method of making drawings, as for example in Fig. 5, was generally employed, but in the early Nineteenth Century it was replaced by the orthogonal method.

Large frictional losses in bearings that supported line-shafts in factories had to be overcome. These in some cases amounted to as much as 75 per cent. of the driving power. Better designs for bearings were sought and eventually this led to the complete replacement of wooden bearings by metal bearings. Their use spread from England to the Continent about 1840, but metal bearings were frequently used on Eighteenth-Century lathes. The introduction of new tools, such as lathes with slide-rests, in the first 30 years of the Nineteenth Century, made a considerable contribution to the manufacture of improved bearings. Fast-running machines with light loads, such as grinding-machines, were fitted with roller bearings in 1803[10].

It is interesting to note that mathematical solutions for mechanical problems in the construction of engines were customary about 1830 since it was desired to design engines with greater accuracy than had previously been possible by empiric methods. Attempts to apply a mathematical approach to the design of bearings were, however, not successful. The pillows were nearly always made of alloys with a high copper content[11], and it was for this reason that they became known as brasses. In 1839 this type of bearing material was further improved by lining it with soft white-metal.

Although attempts were made to produce successful roller and ball-bearings the existing methods for manufacturing them were unable to achieve the required accuracy and strength for successful running. The balls were made by turning on a lathe from a bar, and this method continued till about 1895 when hot and cold pressing-processes were introduced. Ball-bearings were fitted for the first time to a bicycle in 1869, and riders were impressed by the way in which they reduced the required propelling force. Ball-bearings often fractured on workshop machines, however, because the difference in size between one ball and another was too great. They lasted only on bicycles because the loads and speeds were low. This difference was reduced to a safe value between 1885 and 1900 when, after continuous improvement, machines for grinding balls had reached a sufficient standard to give the necessary accuracy of production.

BALL RACES AND OIL BATHS

In order to perfect ball-bearings, extensive experiments were separately carried out (c. 1897) by Professors Goodman and Stribeck and much was learned about the shapes of the races, the tracks in which the balls ran, and the accuracy and finish required for the various parts. The design of plain bearings could by this time be carried out on an established empirical basis, but efforts were still made to simplify the design by evolving mathematical formulae. Beauchamp Tower published the results of some useful experiments on friction in 1883, and his work was followed by that of Osborne Reynolds[12] (1886) who discovered important facts regarding the flow of oil in an oil-bath type of bearing. These facts helped A. G. M. Michell to invent, in 1905, the important type of bearing, which bears his name.

The introduction of new alloy steels and still better production-methods in the first part of the present century brought roller and ball-bearings to a very high degree of efficiency and reliability. Roller bearings, which never really found popularity in the last century, are now successfully applied where loads are accompanied by shock and vibration. Plain bearings, however, are still much in favour where a particular type of load is supported, as for example, that delivered to the crankshafts of Diesel engines for sea and land transport. Fig. 9 illustrates two Twentieth Century bearings: on the left is a roller bearing and on the right a self-aligning ball journal bearing of 1925.

BIBLIOGRAPHY

[1] *Discoveries in Nineveh and Babylon*, by Sir A. H. Layard, 1853.
[2] *Vitruvius Teutch, Libri x*, by Marcus Vitruvius Pollio, 1548.
[3] *Le Navi di Nemi*, by Giudo Ucelli, 1940.
[4] *Codice Atlantico*, by Leonardo da Vinci, c. 1500.
[5] *Le Diverse et Artificiose Machine*, by A. Ramelli, 1588.
[6] *De Re Metallica*, by Georgius Agricola, 1556.
[7] *L'Art de Tourner*, by C. Plumier, 1701.
[8] *Groot Volkomen Mollenbock*, by van Patrus and Leendert, 1734.
[9] *Theatrum Machinarum Molarium*, by J. Leupold, 1735.
[10] *Die Entwicklung der Traglager*, by H. T. Horwitz.
[11] *Practical Essays on Millwork*, by R. Buchanan, 1841.
[12] *Philosophical Transactions*, 1886.

★ ★ ★

Letters to the Editor

PRESERVING CORNISH ENGINES

SIR, The Cornish steam pumping engine was the final development by Richard Trevithick and other Cornish engineers, in 1811, of the single-acting beam engine, which was originally introduced in 1712 by Thomas Newcomen for pumping water from the Cornish mines and which James Watt so greatly improved in 1778. The Cornish Engines Preservation Society was formed in 1935 to preserve from complete destruction the few remaining engines and their houses in Cornwall.

Later, the Society decided to create a Trevithick Site Museum, centred round Camborne, where two large engines of 90 in. and 80 in. cylinders, respectively, and one smaller engine, remain. The cottage, where Richard Trevithick lived for many years, was included in the undertaking. In 1953, a 22 in. Cornish rotative engine, which had worked for over 100 years in the St. Austell district, was presented to the Society by Lord Falmouth and was re-erected in a museum in Camborne, where it works under compressed air. An outlying engine of the Site Museum, built by Harvey and Company, of Hayle, in 1840, for the Levant Mine, near St. Just, is also in the care of the Society.

These engines commemorate the Industrial Revolution in England and the earliest use of steam power in any form. For these reasons, the Society, by means of such funds as they have been able to collect, have taken active steps to preserve the engines and Trevithick's cottage.

To ensure the continuity of the Society's efforts for posterity, an endowment fund has been created, and the trustees of the fund have been appointed by the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Institution of Electrical Engineers, and the Institution of Mining and Metallurgy. The Trustee Department of Barclays Bank Limited, Truro, Cornwall, is the treasurer of the fund, which has been officially recognised by the Chief Inspector of Taxes (Claims) as a charity.

With the endowment fund so established, an approach was made to the Pilgrim Trust by the Society's President, Lord Falmouth, for their consideration of a grant. Following investigations into the purpose and scope of the fund, the Pilgrim Trustees have now made a donation of £500, and this most generous gift constitutes a valuable advance towards the £5,000 target of the fund.

To enable us to achieve this target we earnestly ask all who are interested in the pioneer work of the early Nineteenth Century to contribute towards the endowment fund.

I am, Sir, Yours faithfully,
TREVE HOLMAN,
Chairman.

Cornish Engines Preservation Society,
Camborne,
Cornwall.

★ ★ ★

DR. F. W. LANCHESTER'S BIOGRAPHY

SIR, I am writing a biography of Dr. F. W. Lanchester (1868-1946) for which I have been given material by his brother. I shall be very glad to hear from any of your readers who have personal reminiscences of Dr. Lanchester or documents relating to his life and work.

Yours faithfully,
P. W. KINGSFORD.

Hatfield Technical College,
Roe Green,
Hatfield, Hertfordshire.
December 29, 1956.

★ ★ ★

STEAM CATAPULT

Use by Continental Navies

The steam catapult, designed and developed in Britain, and at present being used operationally in some British and American aircraft carriers, has now been adopted by the Royal Netherlands Navy and the French Navy.

It is being built into the Netherlands aircraft carrier Karel Doorman (formerly H.M.S. Venerable), at present being modernised at Rotterdam, and the French aircraft carrier Clemenceau, now under construction. In Commonwealth navies, H.M. Australian aircraft carrier Melbourne is fitted with a steam catapult and the Majestic-class aircraft carrier Bonaventure, being built in Britain for the Royal Canadian Navy, is being fitted similarly.

The Netherlands carrier Karel Doorman is also to be fitted with another British invention, an automatic aircraft-positioning device. It helps to position aircraft when being prepared for catapulting and speeds up the operation of aircraft at sea. This mechanism has been in service in H.M.S. Eagle and other British carriers for some time. The equipment consists mainly of sets of rollers, fitted flush with the deck, which drive the wheels of aircraft speedily into position for catapulting. Apart from speeding up the operation of aircraft, the positioning device also makes it possible to reduce the size of deck-handling crews. It was developed by the Admiralty at Chatham Dockyard and at the Royal Aircraft Establishment, Farnborough.

ENGINEERING CENTENARIES OF 1957

In the matter of centenaries it would almost seem that, as with wines, there are " vintage years " and others which may be described, like some wines, as being *d'une qualité sans grand caractère*. Compared with 1956 and 1958, the year 1957 partakes of the latter character; yet it is not without anniversaries of note, though many are of an intermediate or introductory significance, rather indicating events to come than being of especial importance in themselves. In this category falls the earliest noteworthy centenary of this year, namely, the resumption of work, in 1257, after an interval of nearly 80 years, on the Naviglio Grande, the great system of irrigation canals in the plain of Lombardy, of which Milan is the industrial centre, which distributes the waters of the River Ticino, the outlet from Lake Maggiore. Just 200 years later, in 1457, the then Duke of Milan, Francesco Sforza, began another important canal, linking the city by a navigable waterway with the River Adda, some 15 miles to the east; this, the Naviglio della Martesana, was completed three years later.

Both of these were considerable undertakings, but not particularly difficult for the mediaeval civil engineer, since they could be constructed " in the dry." Bridge-building, however, especially over a large or fast-flowing river, was another matter; even though the use of the cofferdam was well known, its application was not easy with the primitive appliances of that day. It is probable that few bridges, if any, were as long under construction as the Carls Bridge at Prague, begun in 1357 and finished 150 years later.

UNIVERSITY FOUNDATIONS

The year 1657 was notable for the foundation of two centres of learning, both short-lived, though one was subsequently revived. The Accademia del Cimento was established in Florence by the Grand Duke Ferdinand II for the purpose of undertaking experimental scientific research. It lasted for no more than ten years, but its members did some good work in that short time, including a study of the compressibility of water. The other was the University of Durham, founded by Oliver Cromwell; but the project lapsed at the Restoration, three years later, and it was not until 1832 that the Royal Assent was given to the Bill which established the present University.

When another century had passed, science had advanced on many fronts. In 1757 died an investigator who had contributed to that advance in a variety of fields. René Antoine Ferchault de Réaumur (1683-1757), like the great Henry Cavendish, was a man of ample means and employed his wealth for the furtherance of natural philosophy. When only 24, he was elected a member of the Académie des Sciences. He was eminent alike in mathematics, physics, natural history, metallurgy, meteorology, and, being of a practical turn of mind, in the improvement of industrial processes. He is most generally remembered by the thermometer scale which bears his name, in which he took the freezing point of water as zero and graduated the column in degrees, each of which represented one-thousandth of the volume of mercury contained below the zero mark. As it happened, there were 80 of them between the freezing and boiling points; hence the Réaumur scale.

Leonhard Euler (1707-1783), who has been described by Hans Straub, the historian of civil engineering, as " the most significant and fertile mathematician of the Basle school of the Eighteenth Century," contributed much to the knowledge of physics and mechanics, not least his theory of the buckling strength of struts, published in 1757 in his treatise *Sur la Force des Colonnes*. It was Euler, too, who introduced the symbol e for the base, 2·7183, of Napierian logarithms, and popularised (though he did not introduce) the symbol π for the ratio of the circumference of a circle to its diameter.

A great step towards the improvement of the steam engine was taken in 1757, or rather, two steps, for it was probably in that year that Dr. Joseph Black began the experiments on the latent heat of steam which James Watt was to put to such good use; and it was certainly in 1757 that Watt himself was accommodated with a room in the University of Glasgow and so was enabled to avoid the restrictions which the Guild of Hammermen sought to impose on him, on the ground that he had neither served a proper apprenticeship in the borough nor was he the son of a burgess.

TELFORD AND SMEATON

Two other great engineers, one civil and the other both civil and mechanical, deserve to be remembered in 1957, for it was on August 9, 1757, that Thomas Telford, first President of the Institution of Civil Engineers, was born; and on June 12, John Smeaton laid the first stone of his Eddystone lighthouse. While he was making this great contribution to the safety of navigation (not before time—there were 1,143 wrecks round the British coast even in 1857), another was in hand, for it was in 1757 that John Harrison constructed his third chronometer, the one which he proposed to submit for the reward of £20,000 offered by the Board Longitude. In fact, it was never tried at sea, as he won the award with his fourth chronometer. The making of No. 3 took him 17 years—more than twice as long as his first and second instruments together. It contains (for it is still in existence, with the others, at Greenwich) no fewer than 753 parts, including two roller bearings having steel rollers held in a cage and running in a steel race. It also has a bi-metallic compensation curb, described by the late Lieut.-Commander R. T. Gould (who spent seven years in cleaning and overhauling No. 3) as " the ancestor of all the similar strips now used in the balances of chronometers and high-class watches "; and a remontoire giving " an sbsolutely constant torque at the escape-wheel, whether its driving springs are fully wound, half run-down, almost due for rewinding, or actually being rewound." Harrison got his money, after it had been on offer for practically half a century, but only when King George III personally interested himself to see that justice was done—and even then the Board, which had behaved most reprehensibly throughout, cheated him of £1,250.

NAVIGATION

Astronomy, navigation, and the safety of life at sea are all closely associated, and others of the great names of 1757 were associated with them in that year. Telford comes into this picture, too, for he had much to do with the construction of harbours of refuge as well as with the canals, roads and bridges of his day. In 1757, John Dollond invented his achromatic telescope, often regarded as the first of its kind; incorrectly, however, because Dollond's invention had been anticipated by Chester Moor Hall 24 years earlier, though Hall did not disclose it at the time. Less obviously associated with the science of astronomy—but, it was to prove, quite significantly so—was the defeat of the Duke of Cumberland's forces by the French at the battle of Hastenbeck, on the banks of the Weser, on July 26, 1757; for it convinced a bandsman of the Hanoverian Guards that he was not cut out for soldiering and led him to visit England later in the year, with the intention of remaining there. William Herschel (1738-1822) had been in England before, but only on a short visit. This time he came to stay, earning his living first as a teacher of music and, later, an organist at Bath, but eventually becoming an astronomer of the first rank and the discoverer of the planet Uranus. He detected the new planet on March 13, 1781, and was awarded the Copley Medal by the Royal Society in the same year for this " discovery of a new and singular star." As Arago wrote of him: " It was through music that Herschel was led to the study of mathematics; mathematics in their turn conducted him to optics, the principal and fruitful source of his successful career." In the course of his astronomical work he discovered more than 800 double stars; a branch of astronomy which later attracted the particular interest of Dr. W. H. Maw, who edited this journal for its first 58 years. Herschel, who was knighted in 1816, was the first President of the Astronomical Society (now the Royal Astronomical Society), in which office Dr. Maw followed him 85 years later.

There remain to be mentioned, among the notabilities of 1757, Henry Greathead, builder of the first self-righting lifeboat, who was born in that year; and Sir Samuel Bentham, naval architect and engineer, likewise born in 1757, who, after spending 11 years in Russia, returned to England, was made Inspector-General of Navy Works, and introduced steam-driven machinery in the Royal Dockyards.

The passage of another century brings a number of famous names and incidents into the list. Taking first those who linked 1857 with the century that had gone before, pride of place must be given to William Scoresby (1789-1857), Arctic explorer and surveyor of the coast of Greenland; but not so much on those counts as for his fundamental work on terrestrial magnetism. As early as 1819 he contributed to the Royal Society a paper " On the Anomaly in the Variation of the Magnetic Needle," and he continued to study the subject to the end of his life, though he forsook the sea in 1822 in order to take Holy Orders. His last work, *The Journal of a Voyage to Australia for Magnetical Research*, was published posthumously. He was an early supporter of the British Association, to which he contributed a paper on the height of Atlantic waves.

BASIS OF MECHANICAL FLIGHT

A pioneer in another element, who died in the same year, was Sir George Cayley. He was ten years old when the brothers Montgolfier invented their balloon in 1783, and throughout his life was absorbed in the problems of flight, especially by heavier-than-air machines, which he studied first by observing the flight and the wing structure of birds. The late J. E. Hodgson, who discovered Cayley's missing notebook and edited it for publication by the Newcomen Society in 1933, observed that it was he who, " for the first time laid down the main principle of mechanical flight in the formula, ' To make a surface support a given weight by the application of power to the resistance ' "; though it is only fair to the Right Rev. John Wilkins (1614-72), Lord Bishop of Chester and one of the founders of the Royal Society, to recall that he also declared mechanical flight to be possible " if the motive faculty be answerable thereunto."

Also in 1857 died Dr. Andrew Ure, Professor of Chemistry in the Andersonian Institution at Glasgow from 1802 to 1830, but probably better known as compiler of the *Dictionary of Arts, Manufacture and Mines*; and the French chemist Louis Jacques Thénard (1777-1857), discoverer of hydrogen peroxide and collaborator with Joseph Louis Gay-Lussac in many researches. It was in 1857, too, that the German chemist Friedrich August Kekulé published in the *Annalen der Chemie* his theory of molecular structure in organic chemistry; and that Thomas Hancock published his classic book on *Caoutchouc or India-rubber Manufacture in England.*

BEGINNINGS OF RADIO

Of the scientists and engineers who were born in 1857 the most renowned was Heinrich Rudolf Hertz, the brilliant pupil of von Helmholtz, whose researches in electromagnetism provided the experimental proof of Clerk Maxwell's theories and laid the foundation of the modern science of wireless telegraphy. Three teachers of note who were born in the same year were Professor Karl Pearson, F.R.S., eugenist and mathematical physicist, who died in 1936; Frederick William Sanderson—" Sanderson of

Oundle," of which school he was headmaster from 1892 until his death 30 years later — who made educational history by introducing the study of engineering into the curriculum; and Professor David Allan Low, first honorary treasurer of the Whitworth Society and a former pupil of Whitworth (who was President of the Institution of Mechanical Engineers for the second time in the year in which Low was born), and for 26 years Professor of Engineering at the East London College, now Queen Mary College. Assuredly, no professor was ever more affectionately remembered by his students than he.

In the list of seven Whitworth Scholars appointed in 1877, Low was the sixth. Heading the list was William Isaac Last, also born in 1857, who won his Scholarship while an apprentice with Hayward-Tyler and Company at Luton. With Low, he became a pupil in Whitworth's works at Manchester, meanwhile attending classes at Owens College. After engineering experience on various railways at home and abroad, he joined the staff of the Science Museum and eventually was appointed Director, an office which he held from 1904 until his death in 1911. The Museum was his own contemporary, having been established in 1857, though it was not until 1864 that the first of the engineering collections was formed there.

Many other events of 1857 can be only lightly touched upon. It was in that year that Professor W. J. M. Rankine enunciated his theory of earth thrust, and also founded the Institution of Engineers and Shipbuilders in Scotland, of which he was the first President; that the Royal Society moved from Somerset House into the rooms which it still occupies in Burlington House; that Rudolf Jules Emmanuel Clausius (1822-88) published his work *On the Nature of Heat*, embodying his dynamical theory of gases; that the Thames Conservancy was established; and that *Punch*—of all seemingly unlikely periodicals—appealed for funds in aid of Frederick Scott Archer, inventor of the collodion (" wet plate ") process of photography. Archer died, however, on May 2, 1857.

AND SOME SHIPPING EVENTS

On April 25, 1857, John Laird launched from his yard at Birkenhead the little steamer Dayspring for the exploration of the River Niger, the first vessel to be engined by the firm which is now Cammell Laird and Company (Shipbuilders), Limited, for previously all machinery had been supplied by outside contractors, mainly George Forrester of Liverpool. On September 15, the Union Steam Ship Company's steamer Dane left Southampton for South Africa—the first mail steamer to the Cape; and on November 3 the first attempt was made (unsuccessfully) to launch the Great Eastern from John Scott Russell's yard at Millwall. She had been designed to make the voyage to India via the Cape of Good Hope without fuelling *en route*. Earlier in 1857 laying began of the first Atlantic cable by H.M.S. Agamemnon and the United States screw frigate Niagara; it broke when 380 miles had been laid. It was the Great Eastern which established cable connection with America, in 1866.

Finally, this journal has a special interest in the fact that, in 1857, there arrived in England on his first visit an American, Zerah Colburn (1832-70). He did not stay long, but he came back soon afterwards, eventually returning to America in 1860 on the first voyage of the Great Eastern. A third time he came to England, and on January 5, 1866, published the first issue of ENGINEERING.

★ ★ ★

A co-ordinating Committee on the problems of public health engineering has been set up, the constituent bodies including the Institutions of Municipal Engineers, Public Health Engineers and Water Engineers, and the Society of Medical Officers of Health. The secretary is Mr. P. Arthur Wells and the address of the committee is 90 Buckingham Palace-road, London, S.W.1.

Weekly Survey

Cover Picture: *At Mungyong in the east-central province of Kyongsang Pukdo in Korea there has been built a modern cement works with a capacity of* 200,000 *tons a year. The valley formerly supported only a little farming; now the works will provide the cement for the country's reconstruction and contribute to an expanding economy. Natural resources surround the site: limestone in the hills to the south; the river Yong to the north has the water for the cooling plant and spray pond, and coal will come from a mine in an adjacent valley. The venture, costing* 8·5 *million dollars, is being sponsored by the United Nations Korean Reconstruction Agency (UNKRA), with the United Kingdom, Belgium, Sweden, Denmark and the United States being among the countries providing machinery and materials.*

★ ★ ★

Gas Turbines for the Oil Fields

The Shell Petroleum Company is installing nine gas-turbine generating sets for oil-field power stations in Venezuela, Colombia and Borneo, at an estimated cost of nearly £1½ million. The sets will operate on natural gas from the oil wells. These engines have the advantage that they use little or no water—a big advantage in areas where water supplies are limited. The initial power which they can provide will also contribute towards the production of oil.

Three of the nine sets are already in service. The first one was ordered in 1949 from Metropolitan-Vickers and has completed 5,200 hours of service duty since it was installed in August, 1955. This is a prototype 1,750 kW gas-turbine generating set operating on a simple cycle without a heat exchanger. The combustion chamber is between the compressor and the turbine, giving a straight flow of gases from one end to the other with a minimum of loss of pressure. The axial-flow 15 stage compressor is directly driven at 7,000 r.p.m. The turbine has two stages of rotor blades in Nimonic 80A and two in molybdenum-vanadium steel; the flame tubes round the shaft have each an inner and an outer casing of austenitic steel. The generator is rated at 2,500 kVA and is driven through gearing at 1,200 r.p.m.

There are two American-built 5,000 kW gas-turbines working at the same site and these have been in operation since October, 1954.

A 2,000 kW Dutch set is shortly to be installed and the remaining 5 sets are now on order. The orders are split up among Metropolitan-Vickers, American Westinghouse, Brown Boveri and English Electric. The Westinghouse set has been bought because of promptness of delivery but the English Electric sets are being delivered in record time. The battle in the oil fields between Diesels and gas-turbines would seem to have been joined.

★ ★ ★

Expansion in Terylene

Imperial Chemical Industries is raising production of Terylene by 8 million lb. to 30 million lb. a year. The first benefits from this expansion programme are expected early in 1959. With this new plant, I.C.I.'s total investment in Terylene is about £28 million, but as this latest programme is described as an " interim measure" other and more ambitious plans are apparently in hand. It remains to be seen whether the new and larger scale of production will bring with it a more flexible product or a cut in prices but it will be recalled that, in October, 1955, when the first plant went into full production, I.C.I. reduced prices by 12 to 27 per cent. over the Terylene range. It is becoming clear that a period of increased competition lies ahead for man-made fibres. The announcement in November (see ENGINEERING, October 10, 1956) that Chemstrand Limited were constructing the first section of an Acrilan plant in Northern Ireland is an indication of what is to come.

The enthusiasm for man-made fibres is much more pronounced in Yorkshire than in Lancashire. Last November, Mr. A. J. C. Walters the director of the British Man-Made Fibres Federation, said in Bradford that the woollen-spinning industry took 22 million lb. of synthetic fibre in the first half of 1956 compared with 13 million lb. in the same period of 1955 while the combing industry took 11½ million lb. compared with 7½ million lb. over the same two periods. Terylene has played a part in this expansion and in the closing weeks of the year Terylene net was on show in Nottingham by the lace-furnishing industry for the first time. Lancashire is rather more guarded in its comments upon the future of synthetic fibres in the cotton textile industry. This industry is by far the largest user of staple fibre and it has a longer experience than others of adjusting its machines and products to new fibres. Lancashire is on the whole more conscious of the problems of adjusting its tradition in a natural fibre to the synthetics but, so far as Terylene is concerned, the openings are likely to be more with wool mixtures than with cotton.

★ ★ ★

Prosperity in the Ship Yards

The shipbuilding industry ended 1956 with 6 million tons on its order books valued at about £600 million. This very satisfactory position was slightly marred by the fact that Japan launched a bigger tonnage last year than did the United Kingdom, thus moving ahead of this country into the first position in the world shipbuilding industry. The year, however, ended well for British yards with foreign owners coming back with large contracts now that the Continental shipbuilding yards have reached full employment.

One of the encouraging features of recent weeks has been the indication that this country is particularly well qualified to build super-tankers. Just before Christmas the Shell group ordered two 65,000 ton oil tankers—one from Cammell Laird and the other from Vickers-Armstrongs (Shipbuilders). These are the largest tankers yet ordered in this country. These two ships were originally planned to be only 32,500 tons each under the original Shell expansion programme announced some time ago. Other big tanker owners are also known to be negotiating with shipbuilders for super-tankers to replace ships of smaller tonnage ordered over the last 12 months. It is encouraging that Sir James McNeill, president of the Shipbuilding Conference and deputy chairman of John Brown, on Clydebank, has stated quite categorically in *Lloyd's List Annual Review* that the United Kingdom shipbuilding industry can produce 1,750,000 tons of shipping a year if it can get the steel, a figure which may be compared with 1,542,000 tons launched in 1956. Sir James points out that this country is eminently suitable for fulfilling orders for super-tankers because it has the berths and yard facilities which have been used in the past for large battleships and aircraft carriers. In his opinion, there are half a dozen yards which could build 65,000 ton tankers with their existing facilities, and even larger vessels by further modernisation and adaptation. Sir James is more worried about the provision of repair facilities than about building capacity.

★ ★ ★

English Electric in 1956

The annual review of activities published by the English Electric Company covers a wide range and, as always, impresses with the scope of research, development and production activity which it records. The review would benefit from

a rather more ample treatment of some of the divisions.

In the aircraft division, a production order for the P1B, which is a development of the P1, was announced in November. In the Diesel-engine division full production has been maintained. On the marine side, four Diesels have been ordered for a new fish-factory ship. Among domestic appliances there was a welcome recovery in television business during the autumn. Installation of the first 20,000 kW gas-turbine for the Royal Aircraft Establishment at Bedford has been completed and tests are now in hand; erection of the second of these sets is proceeding. Substantial export orders have been recorded by the hydro-electric department. The biggest and the most recent of these has been a sub-contract obtained from Merritt, Chapman and Scott Corporation in the United States for eight turbo-generator sets and five associated transformers. These are for the Priest Rapids power station in the State of Washington. A repeat order from the Aluminium Company of Canada for a second alternator for their Kemano power house has been received. In the marine department the trawler "Portia" has been equipped with Diesel-electric propulsion machinery and is now serving in the Arctic—the first commercial ship of her type to have this kind of equipment.

The metal industries division continues to reflect the expansion programme of the iron and steel industry both at home and abroad. Important export orders were received from India and Spain, and many of the big iron and steel companies and their subsidiaries have placed important orders during the year for mills of various types. A further cold mill for British Tube Mills was commissioned during the year in Australia.

★ ★ ★

Multiple-Unit Train Formations

A feature of the new multiple-unit trains for the Liverpool Street-Southend line which is less familiar to-day than in the past is the marshalling of the motor coach as the second vehicle from one end of the four-coach unit. The arrangement recalls the three-vehicle London suburban sets of the former London, Brighton and South Coast Railway alternating-current electrification, introduced for the extensions of 1911 and 1912, in which a motor-coach was marshalled between two driving trailers. A somewhat similar formation was seen again in the 1923 and 1924 stock for the extensions of this electrification to Sutton and Coulsdon North, although here the centre vehicle was a bogie power van without passenger accommodation, and it was flanked by two trailers at each end. By a coincidence the General Electric Company manufactured the electrical equipment both for these five-car alternating-current sets and for the new 1,500 V direct-current Southend trains.

Up to now all direct-current stock in this country has had a motor-coach at one, if not both ends, of a unit, though there have been cases of intermediate coaches with motors but no driving compartments, for this feature was introduced in the London Transport tube stock of 1938. It was carried further in the post-war "R" stock for the Executive's surface lines, in which one axle in every bogie is motored. Where very rapid acceleration is of less importance than on the London Transport system, there is not the same need to distribute the motors over the maximum number of axles, and when they are grouped in a single coach there is an argument for not making the motor-coach and end vehicle of the unit. In this way the leading bogie in either direction of travel is non-motored, an arrangement which is often considered beneficial in reducing wear of the track. It would appear to be a simpler way of achieving this result than the use of fully-springborne motors with a flexible drive, on the merits of which opinions are still divided. It means, of course, that the motor-coach is not mobile unless coupled to its driving trailer, but this is a characteristic likely to become more common in the future, as it is probable that designs for 50 cycle motor-coach stock will require power and auxiliary equipment to be distributed between two permanently-coupled vehicles.

★ ★ ★

Another Canal

The steel industry of Lorraine dates from the 1880's, when the Gilchrist Thomas dephosphorisation process made possible the use of the high-phosphorous minette ores. At that time the demand for a water link with the Ruhr via the Moselle and Rhine came principally from Lorraine, as the Ruhr steel makers preferred the rich Swedish ores and the open-hearth process. In 1918, Lorraine returned to France and from then until after the second World War political tension made any ideas of a Moselle canal impossible. In 1950 the announcement of the Schuman Plan revived French hopes and the opening of negotiations for the canalisation of the Moselle from Thionville to Coblenz was one of the conditions in the European Coal and Steel Community treaty in 1952.

Since then, discussions have gone on between France and Germany as a result of which political agreement has been reached. Work on the canal is expected to begin this year. The canal will be some 168 miles long—18 miles in France, 24 miles in Luxembourg and 126 miles in Germany. The cost is estimated at £45 million, of which Germany will pay £25 million. The chief gainer from the scheme will be the Lorraine steel industry, which at present relies on expensive rail transport. The Luxembourg and Saar steel works will receive similar advantages. The Saar and Lorraine coalfields, on the other hand, will face greater competition from Ruhr coal with lower production costs. The other losers will be the German, French and Luxembourg railways, and shipping interests at Dunkirk and Strasbourg.

Some German steel makers complain that the canal represents a hidden subsidy of the kind forbidden by the E.C.S.C. treaty. Others argue that the same sum could be invested to much better purpose to increase blast-furnace capacity in the Ruhr. A third argument is that the canal is a purely political scheme and that no one will use it. If the French calculation of savings of 37 per cent. on coal freights to the Ruhr, and 58 per cent. on rolled steel to Antwerp are correct, this last argument at any rate will be false.

★ ★ ★

A Difficult Year

The difficulties of three companies in widely differing fields of engineering, and the manner in which they were overcome, were described by their chairmen in statements published recently. Mr. H. J. Thompson of Thompson Brothers (Bilston), Limited, who make fabricated steel plant and vessels for the oil, chemical and other industries, reported a fall of £150,000 in his company's turnover to £1·3 million, with a sharply reduced profit. Most of the trouble was due to the difficulty in making good a loss of 25 per cent. in the labour force incurred during a recession in early 1955. This is a striking illustration of the dangers companies face whenever they allow their skilled workers to drift away.

Mr. Thompson mentioned that the situation had now been retrieved and that materials were becoming easier to obtain but, on the other hand, that competition was greater. He also said that "competition is not, however, altogether confined to price"—a statement heard only too rarely nowadays, and intimated that technical superiority was even more important. Mr. F. C. Mosley, of Kendall and Gent, Limited, machine-tool makers, also stressed the serious effect which the shortage of skilled workers had had on his company's production as well as a severe shortage of materials. Nonetheless, Mr. Mosley was able to report a successful year.

Difficulties of a different kind—neither a shortage of labour nor of materials, but a severe recession in demand—were mentioned in the informative and stimulating speech of Mr. George Wilson, chairman of Raleigh Industries Limited. His company achieved an increase of £1·4 million in turnover and a record profit of £2·4 million, despite "rising costs and adverse trading conditions." Raleigh have increased turnover each year since the end of the war; the manner in which they reacted to the Government's measures to reduce home sales is worth quoting in full: "The cycle industy has, generally speaking, experienced a poor year's trading on the home market. The sales figures for the industry are down by approximately 30 per cent. against which our company's sales are down by approximately 15 per cent. Fortunately our export business has been able to take up this slack and has achieved a 27 per cent. increase in sales over last year. Export markets now absorb over 70 per cent. of our total bicycle production." Mr. Wilson mentioned a sharp increase in foreign competition but also further capital expenditure of some £4½ million during the next few years. He expressed confidence that the world demand for bicycles would continue to grow "as the more undeveloped parts of the world are opened up".

★ ★ ★

Steel in the Ascendent

The steel industry has a vast programme of expansion for the year just begun and shows no sign of being deterred by recent international events, or for that matter by the slump in motor car output. More serious, perhaps, since the fall in demand for motor body sheet will mean little more than a reduction in imports, is the forecast of a fall of seven per cent. in expenditure on new building work, since companies will suffer if the level of structural engineering work does in fact fall off sharply. But there is a large unsatisfied demand for plate and for most special steels. A good many engineering companies will continue to be held up through steel shortages this year, particularly if the pressure of demand on the steel industries of western Europe and the United States is such that only token exports are possible.

The financial results of a number of companies published recently suggest that 1956 has been a successful year, and that the industry expects 1957 to be even more successful. Like most of their customers steel makers suffer from continually rising costs, all of which are not being passed on, and from a shortage of liquid resources adequate to keep plant up-to-date and undertake the necessary extensions. There is also a continuing shortage of skilled labour. Mr. Frank A. Hurst, chairman of Samuel Osborn and Company, Limited, commented that "output could be increased if suitable labour was available, as we have good order books in most of our departments."

On the other hand, some companies, among them the United Steel Companies Limited and Dorman Long and Company, Limited, reported lower profits. United Steel's trading surplus (after charging £2·7 million for depreciation) was £12·05 million compared to £12·80 million last year. Dorman Long's corresponding figures (£3·3 million were charged to depreciation, provision for re-lining, etc., and to "replacement reserve") were £7·5 million and £8·9 million, a drop of £1·4 million. The directors of Colvilles Limited stress in their preliminary statement that the effect of increases in the cost of wages, coal and transport "is only reflected to a limited extent in this year's accounts." In their case, however, trading surplus rose by about 9 per cent. and steel output by 7 per cent. The price increase recently granted should enable the industry to have a very good year.

The Engineering Outlook—1

BUSINESS IN 1957

He would be a bold prophet who undertook to outline definitely the prospect for 1957. The international situation alone is capable of changing overnight the basic forces which will mould the business experience of this new year. Even though the outline is obscure, however, it is possible to set out the factors at work and to indicate the pattern which will emerge following certain assumptions. The reader must himself choose the assumptions he prefers.

In the closing weeks of 1956 the overall position was one of prosperity for the present and perplexity for the future, both immediate and distant. Apart from the fuel crisis, the effect of which will be superimposed on the picture later, industrial production was remarkably stable. There were signs that the recession was in some respects past its worst in spite of the none-too-reassuring official statistics for the autumn released a few weeks before Christmas. Motor car production was depressed but had relaxed hire purchase restrictions in prospect. Steel and shipbuilding were booming. The trend of machine tool orders and industrial building activity (both traditional indicators, among others, of the state of the country's economic wellbeing) gave no indications of a significant slowing down of engineering activity (and hence of national prosperity) before the summer of 1957. Exports were at a record level in the autumn months and unemployment was still only about 1·2 per cent. of the working population. The official policy of deflation had created a general shortage of accommodation from the banks, which was inconvenient for many but disastrous for only a few. It had forced workers out of consumer durable goods into foodstuffs and services—and a few, disappointingly few, into engineering. Those few had, however, been a useful reinforcement to the labour supply, making possible an improvement in delivery dates in such industries as machine tools.

Had it not been for the Suez crisis and its lengthening complications, the outlook could have been summed up as follows. There should be a recovery in industrial output in the early months of 1957 followed by a mild investment recession in the later months which would affect the engineering industry in particular, notably civil engineering. The only two factors which could have made the recession more than mild would have been a series of disorganising strikes following breakdowns in negotiations for wage increases, or a failure of official economic tactics to meet the incipient setback in time.

Before going on to record the impact of Suez on such a prophecy, it is worth recording a few of the engineering landmarks which will affect the outlook whatever international complications have to be taken into account. First among them was the official opening of the Calder Hall atomic power unit by the Queen. In 1956, this country began to produce electric power generated from turbines motivated by steam raised by nuclear fission. The arrival of commercial atomic energy in this country, the first to achieve it, is a historic event in its own right.

There have been other events, less spectacular in themselves but nevertheless significant. The decision to give a top priority to the modernisation of the railways (and that is the non-financial significance of the new Bill on railway financing) is an outstanding example of this. The railway programme was started late in 1954, but 1956 assured that the timetable would be fulfilled so far as these things ever can be assured, short of war. Two events in shipbuilding are worthy of special mention. These were the decision of the United States to build an atom-powered merchant ship, and the confirmation of the super-tanker as standard tonnage for the transportation of oil with all the attendant problems of naval architecture and civil engineering which it brings.

EXPORTS INTRIGUING

In order to examine the impact of Suez upon the prospects for 1957 it is first necessary to review the main forces at work which are influenced by the international situation. They are, of course, all intricately inter-dependent but they can be conveniently discussed under the following headings—first, the export position; second, the effect of the external trade position and internal conditions (especially the effect of the labour situation) on industrial costs of production; and third, the state of the trade cycle. The effect of the international situation on each will be examined in turn and its total impact reviewed at the end.

The export outlook is intriguing. As was expected, the boom in the United States has continued, creating with its momentum valuable increases in exports for Western European countries, including the United Kingdom. This country was able to maintain buoyant export levels throughout 1956 in metals and engineering goods. It has often been said in ENGINEERING that the export prospects of this country are tied particularly to the state of trading with the United States and Australia. What of Australia? Immediate prospects are aided by rising wool prices in the Dominion (this was true before the Suez Canal was blocked) and the trade agreement signed in November, 1956 (the first since the one written in 1932 which ran for 24 years) gives Australia a better market in the United Kingdom for its meat, which must benefit Australia's purchasing power. There is another side to the agreement, however, for Australia has given a broad hint that it will not indefinitely maintain the current rate of preference on United Kingdom goods. This market, in the long run, is going to be more difficult to hold on its present scale and the implications for British exports are serious. We have been warned that our stake (and it is a vital one) in the Australian market must not be taken for granted. The improvement in wool price might be temporarily offset by a slight recession in investment in capital goods, however. Such a slowing down is forecast in Australia for 1957 and if it occurs there may be a slight easing in engineering exports to the Dominion. This will represent an easing of pressure, however, on Australian resources, and a step towards a more viable economy—a development which would be welcomed in this country whether import restrictions are quickly relaxed or not.

A second significant issue in the export market is the arrival of full employment in Germany. It was said in this series of articles last year that our export hopes depended much on the impact of full employment in Germany making production costs rise. There are signs that this has occurred. German prices are rising, delivery dates are lengthening and recent dock strikes show that German labour is beginning to feel its power in a seller's market. The days of cheap labour in Western Germany have gone, although it still has big advantages in new machinery (thanks to Marshall Aid) and multiple shift working. Beyond Germany, however, looms Japan which "enjoys" low wages and multiple shift working, a combination which in 1956 enabled it to complete more shipbuilding orders than any other country in the world.

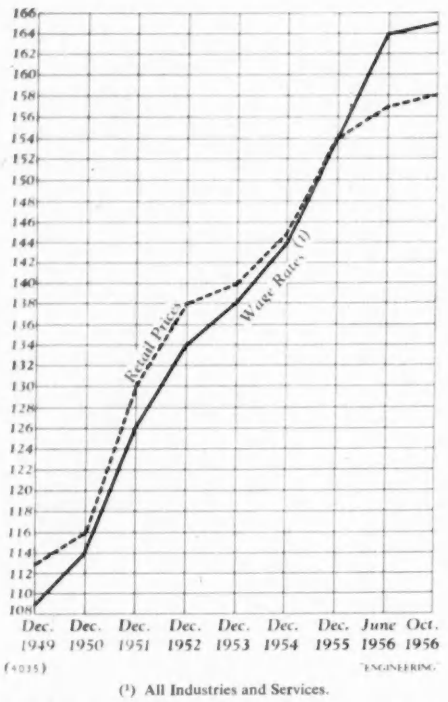
These background facts should be borne in mind when looking at Table I, which shows the exports of engineering goods to different areas of the world. To-day, engineering exports account for 32 per cent. of total exports. Their trend is therefore vital, and the pattern shown in Table I is indicative of the national export position although it is only sectional in coverage. It is clear that the Commonwealth (excluding Canada which is in the dollar area in the Table) is the backbone of the export trade, and only the West Indies, West Africa and the Union of South Africa are not directly affected by the blockage of the Suez Canal, though Cape Town shipments must be delayed by congestion. Turmoil in the Middle East affects about £5 million of United Kingdom exports to Middle Eastern countries in a full year to judge from the Table, but it is the delays to the Far East and to Australasia which are really critical. If the blockage of the Canal is indefinitely long, Japan is bound to benefit, for India and Australia will be forced to buy there if their stocks of machinery and spares run down to danger levels. Fortunately, at the moment, India's stocks are thought to be good, but they are far from inexhaustible.

The other impacts of the Suez crisis have been at work for eight to ten weeks. They are much more easy to enumerate than to evaluate. Freight rates have risen but shipping is scarce. This has meant delays at the docks and a delay in the recovery of the motor industry. Oil cargoes are reduced and therefore the country's very big invisible earnings on tanker freights and oil sales are seriously affected. It was found, rather surprisingly, when the Abadan crisis occurred in Iran in 1952 how vital the level of

TABLE I. EXPORTS OF PRODUCTS OF THE UNITED KINGDOM ENGINEERING INDUSTRY TO SELECTED AREAS (MONTHLY AVERAGES, £1,000)

—	1955					1956 (January to September)				
	Machinery other than electrical	Electrical machinery, apparatus and appliances	Railway vehicles	Road vehicles and aircraft	Ships and boats	Machinery other than electrical	Electrical machinery, apparatus and appliances	Railway vehicles	Road vehicles and aircraft	Ships and boats
U.S.A.	1,219	446	—	1,739	—	1,452	777	—	3,377	—
Canada	1,541	696	149	1,136	156	1,756	1,624	210	1,179	1,136
Dollar Latin America	977	34	—	288	35	1,128	455	—	676	303
Non-Dollar Latin America*	863	298	81	341	—	941	328	177	688	43
Sterling members of the Commonwealth and Dependencies	1,358	1,027	169	1,772	83	1,247	870	268	1,537	224
Australia	4,311	1,754	24	4,469	469	3,873	1,845	355	4,654	218
Union of South Africa	2,758	1,499	400	1,756	160	2,727	1,298	355	1,698	13
Colonies	3,986	2,637	1,219	4,895	93	4,419	2,800	836	5,456	667
Non-sterling O.E.E.C. countries	10,208	2,794	105	5,341	2,387	10,915	3,011	200	6,333	2,536
O.E.E.C. Possessions	484	79	30	396	—	609	89	68	326	—
Eire and Iceland	1,154	354	148	888	40	1,061	300	362	592	30
Soviet Eastern Europe	863	385	—	246	—	835	302	—	34	—
Summary										
Total Dollar Area	3,737	1,621	149	3,163	191	4,336	2,856	210	5,232	1,439
Total Sterling Area	14,430	7,569	1,993	14,121	805	14,268	7,441	2,353	14,625	1,195
Total O.E.E.C. countries	10,692	2,873	135	5,737	2,387	11,524	3,100	268	6,659	2,536
Middle East countries†	1,810	650	6	1,389	—	2,398	1,071	26	1,312	—
Soviet E. Europe	863	385	—	246	—	835	302	—	34	—
Rest of World (residual)	6,888	2,891	88	3,470	1,082	8,549	3,172	864	3,946	1,829
Total exports	38,420	15,989	2,371	28,126	4,465	41,910	17,942	3,721	31,808	6,999

* Peru, Chile, Brazil, Uruguay, Argentine Republic and Paraguay. All other South and Central America classified under Dollar Latin America.
† Israel, Jordan, Egypt, Libya, Saudi Arabia, Iraq, Iran, Lebanon, Syria.



(1) All Industries and Services.

Relative movements in retail price and wage rates since 1949. Index: June, 1947 = 100.

oil shipments was to the British balance of payments. It has to be remembered as well that the good performance of exports in recent years has owed much to trade within O.E.E.C. countries, and these are exceedingly vulnerable to a chronic cut in oil supplies. In consequence, if British industry decelerates for lack of oil (a point discussed below), some of its key export markets will do the same, for it sells to a significant extent to economies partly dependent on oil supplies.

INDUSTRIAL EXPANSIONS CONTINUE

To judge from the determination of the iron and steel industry in pushing ahead with its development programme, industry is not yet unduly perturbed about the long-term consequences of the short-term confusion in the export outlook. It is vital that this confusion should not lead to a hurried modification of expansion programmes in the engineering industry either. If the free trade area is established in Western Europe over the next decade, and the initial response in all quarters to the idea has been very favourable so far, this country's hopes of a larger share in the Western European market depend very much on the engineering industry increasing its competitive power by rapid expansion and the systematic installation of modern machinery during the next few years.

The second heading to be considered is the trend of costs of production. By the late autumn of 1956, costs of production in the engineering industry had reached a highly sensitive level. Profit margins were down and companies were enduring the chagrin of increasing turnover while profits fell. Both raw materials and wages were responsible for the state of affairs and there is little prospect that the situation will ease much in 1957.

Consider first the price movements of raw materials. Reference has already been made to the determination of the steel industry to carry on with the next stage of its development programme. This unaltered policy was announced in December by the Iron and Steel Board when it published the new range of steel prices. The engineering industry will have to absorb increases of anything up to 10 per cent. in the price of steel this year. The average increase is only 6 per cent., but the advance has been more marked in heavy than in light steel products. Fortunately, steel stocks with consumers are still high, and it may be some time before the new prices affect production costs seriously. On the other hand, the increases announced in December, 1956, took no account of the effect of the international situation, and if the Canal is not re-opened fairly quickly, the steel industry will find its unit cost of production rising as fuel becomes more scarce. It will be surprising if such increases are not passed on to the user industries.

NON-FERROUS METALS

The prices of lead and zinc moved up sharply when the Suez Canal was blocked, but it is difficult to imagine the price of lead in particular remaining buoyant unless there is a fairly quick end to petrol rationing. In the short run, there is no reason why the public should renew their car batteries more slowly because of petrol rationing, but this will certainly happen if rationing continues for more than a few months. A serious decline in the rate of car battery replacement would soon work itself out on the demand for lead in this country and prices would tend to fall. Over both lead and zinc, however, there now hang the implications of the British Government's decision in the spring of 1956 to reduce strategic stocks. No official pronouncement has been made about the volume of these metals likely to be disposed of on the market, but it has been estimated that about 20,000 to 30,000 tons of each may be involved. This represents about 50 per cent. of slab zinc held for stock commercially in the later months of 1956, or about two months' consumption. In the case of lead, a figure of this size represents about 50 per cent. of the commercially held stocks of imported virgin lead and English refined lead, or one month's consumption. These are substantial quantities. The effect which they might have on lead and zinc prices would of course depend on the rate at which they were released, but it seems likely that the operation will take place over the first three months of 1957. One way and another, there are considerable forces at work which could force the price of lead and zinc slightly lower over the early months of 1957. Thereafter, if industrial production in general revives and, as is likely, industrial stocks have been run down to some extent, there might be a significant price recovery over the summer.

Tin prices must be particularly sensitive to the blocking of the Suez Canal. Prices went up by about £100 early in November, 1956, to over £800 a ton. Within one month, however, of this sudden jump in prices the United Kingdom Government announced its intention to release tin from the stockpile. About 2,500 tons of tin is involved in this operation and it seems likely that this disposal will eliminate Government stocks. The official announcement about their release brought tin prices down sharply, and it is clear that, at the beginning of 1957, the tin market as a whole is in a highly sensitive condition in which the international situation is by no means the only determining factor.

END OF NICKEL SHORTAGE?

There is some possibility that 1957 will see the end of the chronic shortage of nickel. Late in 1956 the International Nickel Company of Canada announced that it would spend 175 million dols. in Northern Manitoba developing the nickel deposits at the Mystery-Moak Lakes. This will be the largest nickel-producing undertaking in the world, after that company's operations in Ontario. By 1960 it is expected that the world nickel capacity will be over 300,000 tons a year. Meanwhile there is the prospect that the Nicaro Company, which is now recovering nickel from the Moa Bay laterite ores in Cuba, may make a useful contribution in the immediate future to nickel supplies.

No metal has had a more chequered career in the past few years than columbium. It is required for heat resisting steels in gas-turbine engines, and it is one of the nuclear elements in atomic feeder reactors, but despite these long-term assurances of a steady market, its past has been very unstable. The United States Defence Materials Procurement Agency offered a bonus of 100 per cent. in 1952 on columbite in order to build up the United States strategic stockpile. The bonus was abruptly withdrawn when the stockpile was achieved, and the price then slumped. Efforts are being made to prevent the price falling below £700 per ton for ore containing 70 per cent. combined pentoxides, but further pressure on price is building up. In the middle of 1956 discoveries of important deposits were announced both in Canada and Uganda. There seems little likelihood that demand will be able to absorb the forthcoming supply if prices are kept artificially high.

Towards the end of 1956 and before the Suez Canal became blocked, the price of copper was moving steadily downwards. The international situation brought about a reversal of the trend, but copper prices responded more sluggishly to the blockage than did other base metals. Indeed, by the end of December the Rhodesian Selections Trust had begun to quote £270 per ton for copper delivered c.i.f. United Kingdom electrolytic wirebar basis for delivery direct to customers. It is known that this price of £270 represents to the Rhodesian copper companies about £10 a ton below a comfortable price. Any decline below £280 is considered something of a threat to profit margins. The copper market is thus comparatively depressed at the moment and may move sensitively in either direction in response to the international situation, strikes at the mines or changes in re-stocking policy by users. It is not likely that there will be an abrupt upward movement in copper in 1957 even if the international situation remains tense. For the time being there is no lack of copper and world capacity is expanding. If prices are not likely to move upwards steeply this year, it is also unlikely that there is a marked long-term downward trend. The long-term outlook for copper is good and one American estimate looks forward to an increase of 46 per cent. in the consumption of copper outside the Soviet sphere of influence between 1956 and 1965.

Aluminium is at a critical point in its career as an important raw material for industry. Ever since the war, when the aircraft industry gave it an unparalleled opportunity to establish itself on a much bigger scale than ever before, world demand and supply have moved steadily forward. Now, at the beginning of 1957, the industry faces a major period of expansion which will be justified only if the outlets for the metal are increased in size and number. The United States in particular is expanding capacity rapidly, and British industry must face the possibility that before long the American industry may become a net exporter. The record of aluminium in recent years (both here and abroad) is good in research and salesmanship, and the metal may make notable progress especially against the other non-ferrous metals, particularly if the latter rise in price. The existence of a growing world aluminium capacity could, indeed, be something of an insurance for some users of non-ferrous metals that prices of the latter will not go too high.

PLASTICS EXPAND STEADILY

Sales of plastics materials have been kept buoyant over the last year by the expansion of the export trade. Even the buoyant export record, however, was not sufficient to prevent at least a slackening in the rate of increase in plastics output over 1956. Nevertheless, the fact that the expansion in plastics was no more than retarded by the serious setback in the turnover of consumer durable goods in 1956, suggests that the industry has now achieved a long-term steady rate of expansion which will be upset only by a severe trade depression afflicting all industries. The industry is looking forward to raising its output from 300,000 to 500,000 tons a year over the next 5 years. Since it is highly capitalised and benefits from the economies of large scale production, there is reason for thinking that such an expansion can be achieved in many plastics lines without prices rising as far as those of competitive old-established

materials. One of the effects of the 66⅔ per cent. increase in the output of plastics might be to increase the price of zirconium among the minor metals, especially as zirconium is important as a structural material in nuclear reactor furnaces.

It would seem that the pattern of raw material prices for 1957 could be exceedingly complex. The position of steel prices is quite clear, but among the non-ferrous metals prices might stay fairly stable in the early part of the year. The blocking of the Suez Canal, and possibly a lower scale of output among industries processing raw materials, will tend to put prices higher but there are certain long-term factors in favour of user industries; the unloading of strategic stocks on the market may also have a dampening effect for the next few months. If the Suez Canal is cleared early in 1957, raw material prices may not advance very steeply despite the continuing American boom.

COST OF LIVING AND WAGE INCREASES

So far as wages are concerned, the early months of 1957 will be critical for the outlook over the year as a whole. Early in January, 1957, the engineering union representatives are meeting in York to consider their attitude to the employer's refusal to consider a 10 per cent. increase in wages. Before that occurs, however, the British Transport Commission is likely to have received an answer from the A.S.L.E.F. about its offer for a 3 per cent. increase, an offer which has also been made to the N.U.R. Behind these decisions lies the final outcome of the offer made to provincial bus operatives also for a 3 per cent. increase. It is clear that if the attitude of these unions in January is conciliatory, a conventional figure of 3 per cent. may become established in the early part of the year and might become fashionable enough for the engineering unions to accept. It is apparent from the manoeuvring at the end of 1956 that the N.U.R. wishes to know the reactions of A.S.L.E.F. to the 3 per cent. offer before it makes an official reply itself. In turn, A.S.L.E.F. might be influenced by the provincial bus operatives. In the closing days of 1956 there seems to be an opinion emerging from the engineering unions that they will, in fact, settle for something between 3 and 4 per cent., provided that the industrial climate in general does not take a turn for the worse. There seems little doubt that the international situation is working in favour of moderate opinion within the engineering unions and that the union executives do not really expect to get their original demand. From the point of view of costs of production this is something of a gain for, at the moment, it looks as though a demand for 10 per cent., backed up by militant action (though cooler councils were expected to prevail on this issue in any event) has been replaced by a demand for 3 or 4 per cent. and a willingness to go to arbitration.

TABLE II. *Employment in the Metal Manufacturing and Engineering Industries of Great Britain (Thousands)*

—	September, 1955	September, 1956
Metal Manufacture	503·5	510·3
Blast furnaces	20·9	21·9
Iron and steel melting, rolling, etc.	204·7	211·0
Iron foundries	109·2	105·9
Tinplate manufacture	11·9	12·5
Steel sheet manufacture	20·3	20·7
Iron and steel tubes (incl. melting and rolling in integrated works)	41·0	44·3
Non-ferrous metals, smelting, rolling, etc.	95·5	94·0
Engineering, Shipbuilding and Electrical Goods	1,610·3	1,633·2
Shipbuilding and ship repairing	199·7	203·8
Marine engineering	76·7	76·4
Agricultural machinery (excl. tractors)	36·3	34·5
Boilers and boiler-house plant	28·6	29·0
Machine tools	93·0	96·2
Stationary engines	24·0	24·9
Textile machinery and accessories	55·3	52·3
Ordnance and small arms	49·8	48·4
Constructional engineering	78·3	79·8
Other non-electrical engineering	538·7	552·7
Electrical machinery	140·9	146·9
Electric wires and cables	41·6	41·4
Telegraph and telephone apparatus	34·0	35·6
Wireless apparatus (excl. valves) and gramophones	74·8	72·0
Wireless valves and electric lamps	25·1	24·2
Batteries and accumulators	11·6	11·1
Other electrical goods	101·9	104·0
Vehicles	1,029·1	1,010·7
Manufacture of motor vehicles and bicycles	286·9	264·0
Motor repairers and garages	247·1	247·7
Manufacture and repair of aircraft	210·6	220·8
Manufacture of parts and accessories for motor vehicles and aircraft	128·2	122·5
Locomotive manufacture	72·0	70·7
Manufacture and repair of railway carriages and wagons and trams	79·5	80·3
Carts, perambulators, etc.	4·8	4·7
Metal Goods not elsewhere specified	325·3	329·4
Tools and cutlery	26·7	26·5
Bolts, nuts, screws, rivets, nails, etc.	24·2	24·9
Iron and steel forgings, not elsewhere specified	34·0	35·2
Wire and wire manufacture	29·8	30·3
Hollow-ware	27·5	27·4
Brass manufactures	31·8	32·0
Metal industries not elsewhere specified	151·3	153·1
Precision Instruments, Jewellery, etc.	89·6	90·6
Scientific, surgical and photographic instruments, etc.	57·3	59·0
Manufacture and repair of watches and clocks	9·6	9·1
Jewellery, plate and refining of precious metals	15·4	15·3
Musical instruments	7·3	7·2

There are certain implications in this percentage figure, however, which must be borne in mind. In the recent past, the engineering unions have pressed their claim on grounds of higher profits, rising productivity and the rising cost of living. It is obviously difficult for them to pursue the argument under the first two headings. Over the last 12 months there has been a slight increase in employment in the engineering industry as a whole and some quite significant increases in output. There have been, on the other hand, dismissals from some engineering companies and a severe reduction in the amount of overtime worked. Some operatives have been on short-time for several months. Most engineering companies are beginning to show in their accounts the effect of rising costs on their profit margins, despite rising turnover. Under these circumstances it is not easy for the unions to argue very convincingly either to the employers or to their own members about higher output per man justifying bigger wages. Increasingly, therefore, the argument becomes based upon the cost of living. Between March and October, 1956, the official retail price index moved up 3 points, or just under 3 per cent., and the index may perhaps be presumed to have rounded off the 3 per cent. increase by the end of 1956. The figure thus has a familiar ring about it. It would be possible for the chain of wage demands which are now in various stages of negotiations to become tied to this figure and so set the pattern for 1957. It may be, however, that the pattern will not become fixed to 3 per cent. but to the retail price index itself which could conceivably advance sharply later in the year. If that should occur, industry in general and the engineering industry in particular might find itself faced with supplementary wage demands later in the year because the cost of living index had risen. In this event, the unions might have used the recent level of the cost of living index as a very useful thin end of the wedge, and in such circumstances a restrained and public spirited 3 per cent. in January could turn into a rather more dangerous opportunist additional 3 or 4 per cent. in the summer.

COMPROMISE TEMPTATION

The employers were adamant in the late autumn that they would not consider any increase at all. A sudden moderate demand from the unions, especially if they hinted that they would be prepared to accept arbitration in the matter, might put the employers in a difficult tactical position. It is not easy to resist the offer of a moderate compromise settlement, especially if arbitration is mooted, and the employers may well think that the risk of strike action with inevitable interruptions to production in a difficult year is not worth taking. If this should be so, wages will rise and wage costs per unit of output will probably go up with them unless the Suez blockage is quickly removed and industrial output is not jeopardised. There is a prospect however, that some engineering companies may have to carry a larger wage bill on a smaller turnover for at least a few months in 1957.

The prospects that an increase in the wage bill will have been due, at least in part, to an nflux of labour rather than to higher wages has improved slightly owing to the Suez crisis. Between June, 1954, and September, 1956, the engineering, shipbuilding and electrical goods industries raised their labour forces by 6 per cent. compared with an increase of the working population of 3½ per cent. Employment was slightly down over the same period in motor vehicles and there was an increase of only 1½ per cent. in numbers employed in the metal industries. There was thus a modest though perceptible movement of labour in the direction of general and electrical engineering up to the autumn of 1956. Since then, output has fallen further in the motor vehicle industry and there is the prospect that industries dependent on oil will also have difficulty in maintaining output. Under those circumstances the engineering industry might get another modest influx of labour in the spring, which would not have occurred without the Suez crisis. It is by no means certain, however, that this will happen and that the net change in the switch round of jobs will be to the advantage of the engineering industry as a whole. Pools of labour may be created up and down the country from which engineering concerns can recruit, but some engineering companies themselves may be hard put to it to maintain output and keep their force intact. In any case, one of the lessons of the mild recession of 1956 is that after a period of full employment, companies are loathe to part with their labour and when they have to let men go, they hang on to those who would be most wanted in the labour market.

The last heading under which prospects have to be considered is the trade cycle. At the present time, had it not been for Suez, industry might well have got over the 1956 phase of the trade cycle, a cycle induced of course by Government policy. That policy produced a definite decline in the output of consumer goods, and the money which the public did not spend on them went to some extent on foodstuffs and services. Labour dislodged from the consumer durables industries moved into the other group, a change which was neither desirable nor intended. A certain amount of labour, but not really enough, went into the right industries, including engineering.

A further consequence of the official policy, however, was to set back building investment, notably industrial building. Housing, too, is easing off and this may release more labour for other work. Meanwhile, the drop in the number of industrial building schemes approved will be felt in a shortage of work in the second half of 1957. A lack of expansion in building capacity transmits itself in due course into a demand for fewer machines. A fall in the orders for them would probably not occur until later in 1957 but the trend of coming events would show up earlier in a smaller rate of expansion. This drop in investment could generate a general fall in industrial activity in early 1958. The time to put counter-measures into operation would be the time of the budget in April, 1957, giving these measures the summer and autumn to gather impetus to offset the effect of events likely to follow from the credit squeeze of 1956.

WITH AND WITHOUT SUEZ

The pattern without the Suez crisis would thus possibly have been as follows: a gradual recovery over the winter of 1956/57, a flattening out of activity over the summer, a slight decline through the second half of 1957 in the capital goods

industries (that is, engineering) followed by a general recession in 1958 if the Government did not try to stop it about budget time in 1957.

What has the international situation done to this programme? First, the recovery through this winter will not take place. If tension is little changed for some time (which is probable) the physical state of the Suez Canal is all important: it is not likely to be cleared completely before March on the most optimistic assumptions. If it is cleared, the country will have had three or four months of mild despression in output and a mild bout of inflation in money values. The impact of the blockage on imports will be apparent but not desperate, for imports may fall more quickly then exports, thus helping the balance of payments position. Either there will be growing unemployment and few wage demands, or little unemployment with the unions still out to make a bargain and a slightly easier position in the labour market. There will be time, in short, for the Government to develop an expansionist policy before the economic effects of the crisis join forces with the flattening out of activity in the summer—which was coming in any event. There will be time to save 1958 from depression. There is not time probably to prevent 1957 from being a year of some dislocations and bad prospects in the second half (as distinct from good current results for many sections of the engineering industry). The weeks just before the budget are therefore critical for both 1957 and 1958 for the engineering industry and the economy as a whole.

It would appear that Suez crisis or no Suez crisis, petrol rationing or no petrol rationing after April, the spring months of 1957 will be critical ones for British industry. In those months decisions will have to be announced to make things a great deal better or a great deal worse.

STORING FUEL OIL

Heating Requirements and Fire Risks with Heavy Grades

In a paper entitled "Storage of Fuel Oil" presented to the Institution of Heating and Ventilating Engineers on December 5, Mr. T. Chippindale, Assistant Fuel Oil Manager, Shell-Mex and B.P., Limited, discussed the best ways of storing the heavier grades of oil that are now being used in this country. In the period before 1939, he said, the most commonly used heavy grade of oil had a viscosity of 200 seconds Redwood No. 1 at 100 deg. F. To-day, that most commonly used has a viscosity of 950 seconds Redwood No. 1, but grades up to 3,500 seconds have been introduced in the last two or three years.

As regards methods of delivery and storage capacity, the author considered that these two were inter-dependent from the point of view of the advantages obtainable by taking full loads, and suggested that the generally recommended capacity was equivalent to three weeks' supply at the maximum rate of consumption or to the customary quantity for a delivery plus a reserve equal to two weeks' consumption, whichever was the greater.

The present smallest road tankers carried 1,200 gallons, but in the future there would probably not be any below 2,000 gallons. Rail cars carried 20 tons (about 900 gallons) in the majority of cases.

As regards the temperatures at which oil could be stored or handled, the minimum temperature should be used at which it was an economical proposition to pump the fuel. For gas-oil no heating was required either in storage or in preparation for atomization; 220 second oil should be stored at about 45 deg. F.; 950 second oil at 65 deg. F.; and 3,500 second oil at 100 deg. F. The heat losses from the storage tank depended on the temperature of the oil, the situation of the tank and the amount of lagging applied. The viscous oil formed a fairly static layer against the sides of the tank, which had an insulating effect.

Mr. Chippindale said that the usual methods of heating were by thermostatically controlled steam coils, hot-water coils or electric immersion heaters. The use of heaters on the out-flow or suction pipe allowed heavy oils to be stored at a comparatively low temperature while yet remaining pumpable for delivery. Such arrangements were coming increasingly into use.

Storage tanks should normally be fitted with a filling pipe which should be as short as possible, and tanks should not be connected together, but should have a separate filler for each. Each tank should also have a vent pipe, again as short as possible, and not smaller in bore than the filling pipe, and a drain or sludge valve at the end of the tank far from the draw-off point. The so-called horizontal tanks should always be installed with a slight slope towards the drain valve. For some installations ring mains were used to supply the burners and these sometimes required separate heating to maintain a free flow of oil within them. There also should be a fire valve, preferably situated within the tank chamber or catch-pit, which could be used to drain back any oil from intermediate service or storage tanks or from the ring mains.

The majority of tanks were of welded steel construction, and this was usually recommended, but concrete tanks were also being used on account of the shortage of steel and delay in delivery. For concrete tanks adequate reinforcement was required to prevent cracking during any settlement of the structure. Various methods were available for rendering the concrete oil-tight. On the Continent, glass-lined tanks had been in use for some years, and some were being built in this country. As regards location, the author emphasised that the fire risk in connection with oil-storage tanks was from a fire in the vicinity of the tank and not primarily from the oil within the tank. Consequently, tanks should, if possible, be installed in the open and above ground with catch-pits around them capable of taking at least 10 per cent. more than the capacity of the tank. The petroleum safety regulations only applied to fuels having flash points lower than 73 deg. F. and therefore did not apply to fuel oils whose flash points were always higher than 150 deg. F. Codes of practice have been laid down by the Fire Officers' Committee, based on B.S.799:1953, but the London County Council had their own requirements, which were well worth following.

★ ★ ★

OFF-SHORE BORING

Progress in Locating Coal Seams

The off-shore boring tower for use in the Firth of Forth was described in ENGINEERING, vol. 179, page 674, 1955, in some detail. Information Bulletin No. 56/172 of the National Coal Board describes the whole of the off-shore boring project, including the tower and the layout of the coal fields of that particular area. It also describes the work that has so far been carried out. The tower was grounded in its first position in May, 1955, and was found to be only 45 minutes out of the vertical when it came to rest on the sea-bed. Boring began on May 29, and continued until November 11, at which date a depth of 3,161 ft., measured from the drilling platform, had been reached. Troubles were encountered due to inadequate sealing of the guard tube when it was first lowered into the mud, but satisfactory samples of the strata were obtained. The presence of the "five foot" seam was proved at 2,915 ft.

To ensure the safety of future underground workings, it was essential that the bore-hole should be carefully sealed, thus apart from the economics of salvaging the lengths of casing it was necessary to withdraw them in order that a seal could be made with injected cement, particularly where the strata were porous. Lifting the casing took two months, and some of it had to be abandoned. The hole was sealed by pumping a thick slurry of Ferrocrete cement through the drill rods. The sealing was done in stages, each following the withdrawal of a section of the casing, and where the casing had not been withdrawn it was perforated with a special tool to ensure that cement could reach the surrounding ground.

A tentative position for the second bore hole, approximately one mile from the first, had been chosen, and the sea-bed was inspected there to make sure that it was level. Preparation to move the tower to the new site began on April 9, 1956, when the strops were connected to the girder base. The pontoons were brought into position on April 17, reaching the site at 10 a.m. Lifting began by 1.50 p.m. and was complete within an hour without any difficulty. At 3.20 p.m. the tower was on tow to the new site; at 4.10 p.m. the pontoons were moored to the flanking buoys and at 4.30 lowering began. At 5.30 the base was resting on the sea-bed, and an hour later the tugs began to tow the pontoons back to Burntisland harbour. After the tower had grounded it was found that its inclination to the vertical was 1½ deg., but this was not considered sufficiently serious to interfere with the boring of the hole. It is believed to be the first occasion when an artificial island once placed in the sea has been successfully raised, moved and re-positioned.

★ ★ ★

NEW PREMISES OF THE I.CHEM.E.

After twenty years at 56, Victoria-street, the offices of the Institution of Chemical Engineers have now been transferred to 16 Belgrave-square, London, S.W.1. A recent visit to these premises showed that the Institution staff have settled down in their new home which has been adapted for its purpose as the headquarters of a learned institution. A lift has been put in to serve the two upper floors of the building and as Mr. John A. Oriel, C.B.E., M.C., the President of the Institution, stated during our visit, the Council hope that the space now afforded will prove adequate for many years to come. He added that the Institution owed a debt of gratitude to the Society of Chemical Industry, which had purchased Nos. 14, 15 and 16 Belgrave-square and had offered them the tenancy of No. 16. Thanks were moreover due to a number of firms who had made it possible to furnish the premises.

Mr. Oriel further stated that, at the present time, in this country, some 300 qualified chemical engineers were made available to industry every year. Something of the urgency of the training problem and the need for enlarging and augmenting the educational facilities could be gauged from the fact that, by 1965, the yearly total of trained chemical engineers needed would be between 1,200 and 1,500.

★ ★ ★

NORTH OF SCOTLAND POWER

Another 9,200 kW of generating plant has now been brought into use by the North of Scotland Hydro-Electric Board. The largest single unit is the new power station of 6,000 kW at the mouth of the Allt-na-Lairige. The generator of this station is driven by a twin runner horizontal Pelton machine and is remote controlled from the Shira scheme. The new power station at Achanalt has a capacity of 2,400 kW and the output is controlled automatically by the level of the water in the head pond, or manually from Grudie Bridge so that normally the station will be unattended. The remaining 800 kW will be produced from a third generator installed at Storr Lochs.

AN IRON FOUNDRY ENLARGED

WIDE RANGE OF CASTINGS FOR MACHINE TOOLS

In March, 1947, the B.S.A. Tools Group acquired the concern now known as the Cardiff Foundry and Engineering Company (1947), Limited, in order to ensure a continuous supply of grey-iron castings of high quality for their machine-tool workshops at Mackadown-lane, Kitts Green, Birmingham 33. Of late years increasing demands for iron castings have made extensions at Cardiff necessary and these have been completed recently, resulting in a great increase in capacity, the foundry producing castings ranging in weight from less than one pound to 8 or 9 tons.

The main foundry building now measures upwards of 600 ft. in length and is some 60 ft. in width. In addition, there are a number of annexes running the full length of the main building and at each side of it. These annexes are used for preparation and finishing operations, and the whole foundry occupies an area of 95,000 sq. ft. The main bay of the foundry is divided into three sections, one dealing with heavy moulding work, another with machine-moulding work and the third with high-speed repetition casting work in which a mechanised conveyor unit is employed. This conveyor is made up of 88 casting plates and is served by four jolt-squeeze moulding machines, one of which is seen in Fig. 1. As will be noted, moulding sand is fed into the box from an overhead hopper, the sand being delivered by ceiling-height conveyors from the sand-mixing mills. The actual hopper loading from the conveyor is automatic. After ramming, the pattern is removed, the mould is trimmed and the box placed on the conveyor for transportation to the casting stage.

The larger moulding boxes are filled by two sand-slinging machines, the hoppers of which are also charged from the overhead sand conveyor. One of these sand-slinging machines works in combination with a large roll-over unit having a capacity of 10 tons and capable of handling moulding boxes measuring up to 8 ft. by 5 ft. The other sand-slinging machine works at radii of up to 12 ft. 6 in., and has a vertical movement of 3 ft. The last-mentioned machine is seen in Fig. 2.

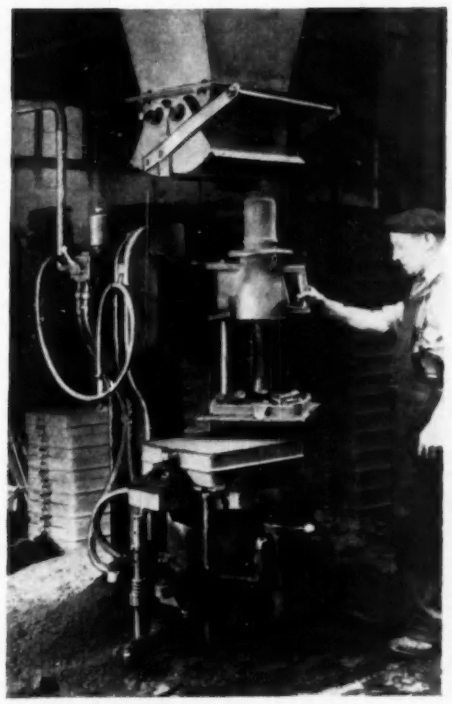
Three cupolas make up the foundry melting equipment and they are in use alternately. The cupolas are tapped in an annexe building and the molten iron run into the foundry by means of feed chutes. The charging of the cupolas is accomplished by means of conveyor buckets from a gallery above the annexe. The molten metal from a cupola is directed into ladles suspended from a mono-rail gantry. The larger containers are taken by overhead cranes to the section devoted to the manufacture of the larger castings. Other ladles are used for direct pouring into moulds standing on the mechanised conveyor or for refilling smaller ladles used at various points in the foundry. After casting, the moulds are off-loaded from the conveyor by a pneumatic ram on to a shake-out grid at the knock-out point. The grid has a capacity of six tons and the sand removed from the mould by the vibration of the grid falls into an underground collecting station.

At one side of the foundry there are seven large mould and core drying stoves which are thermostatically controlled; the fuel employed is coal, fired by means of automatic underfeed stokers.

The fettling shop houses a Wheelabrator shot-blasting machine consisting of two 6 ft. diameter rotary tables, each capable of accommodating up to two tons of castings. The spent shot is reclaimed through a grid in the floor of the chamber of the machine, whence it is collected by an underground conveyor which feeds a lift conveyor. This returns the shot to the hopper of the machine.

After shot-blasting the castings are trimmed or ground, as may be required, and are then passed on to paint-spraying booths where they receive a coating of priming paint prior to dispatch.

In keeping with modern ideas in this matter, automatic dust-extraction equipment is employed extensively, not only in the fettling shop and in the region of the knock-outs, but also throughout the works. Another outstanding feature of the installation is the sand-reclamation equipment. From the knock-out grids the sand is received in underground containers from which belt-type conveyors transport it to the "sand house" where new sand is added and the material raised by bucket-type elevators into a hopper of some 50 tons capacity. At the base of the hopper a controlled rotating table directs the sand on to one of two conveyor belts which take it to one of two mixing mills. At this stage various bonding chemicals are accurately measured and added to the sand in the mill, together with controlled quantities of water to maintain the correct moisture content. From the mills the sand is fed to the main conveyor belt running the full length of the main foundry, from which it is redirected, as required, to the various hoppers of the moulding machines below.



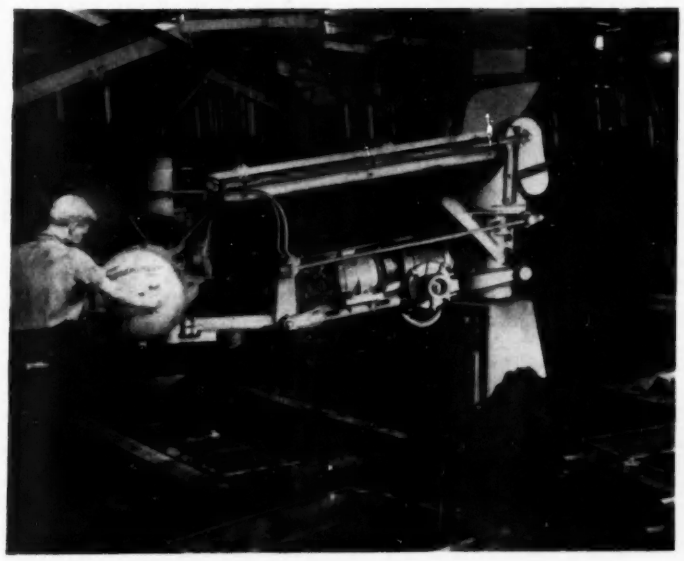


Fig. 1 (above) A jolt-squeeze sand moulding machine serving the mechanised conveyor unit producing repetition castings.

Fig. 2 (left) A sand-slinging machine, working at radii of up to 12 ft. 6 in., filling a large moulding box.

★ ★ ★

INFORMATION CENTRE FOR APPLIED MATERIALS

With a view to providing accurate data regarding the mechanical and physical properties of applied materials an Information Centre has been established at Farnborough, Hampshire. Samples of materials from various fields of technology, comprising ceramics, refractories, alloys, wood products, low and high-temperature thermal-insulation materials, glass-reinforced materials and various fabrics, together with "material data cards", are now on display. The data given cover mechanical, electrical and thermal properties, the weights and dimensions available, the costs and details of fabrication and machining, the sources of supply, and references.

The aim of the organiser of the Centre is to concentrate, under one roof and for the benefit of designers, production engineers, and others, samples and data regarding modern applied materials.

Further particulars and information regarding the services of the Centre may be obtained from Mr. P. Bishop, the Information Room, c/o the Farnborough and Cove Universal School of Motoring, 6 Queen's-road, North Camp, Farnborough, Hampshire. (Telephone: Farnborough 2323.)

★ ★ ★

MARINE DIESEL ENGINE

The Thames tug Sun XIX, which recently went into service, is propelled by the first of a new range of marine Diesel engines made by Ruston and Hornsby Limited, Lincoln. The range is an adaptation of the standard industrial type of the vertical four-stroke direct-injection design, and will be known as the series VLB. Cylinder numbers will range from 5 to 8, and the engines having 6, 7 and 8 cylinders will also be available in supercharged versions. Horse-powers on the 12 hour rating range from 605 for the 5 cylinder normally aspirated model, to 1,451 on the 8 cylinder supercharged model, when measured at the gearbox coupling. Engine speeds are 375 r.p.m. In the tug, the Mark 6 model is used, developing 1,090 s.h.p. and driving through a Modern Wheel Drive, oil operated reverse-reduction gearbox of 3 to 1 ratio. This gearbox incorporates hydraulic shaft brakes which operate automatically in the neutral position. The engine employs closed-circuit fresh-water cooling in which the double-bottom tank acts as a heat exchanger, thus avoiding the intake of contaminated raw water.

EXHAUST PULSE ENERGY

UTILISATION OF DIESEL ENGINE GASES IN TURBINES

By W. A. Pullman, PH.D., A.M.I.MECH.E.

Increasing interest is being shown in the utilisation of blowdown energy in the form of pressure waves, and this interest is likely to grow as the turbo-charging of two-stroke cycle engines becomes more widespread. One method which has been proposed consists, as shown in Fig. 1, of dividing the exhaust physically into two parts and leading the first portion of the blowdown gases—or pre-exhaust—to a turbine, while the main exhaust is discharged directly to atmosphere. Such a system posseses a number of advantages over conventional methods particularly with respect to scavenging. In the following article a method is described for determining, by means of a step-by-step procedure and the use of charts, the blowdown pulse energy and hence the output of an exhaust turbine.

Some simplifying assumptions have been made in the analysis in an attempt to keep the amount of labour involved to a minimum and make the method suitable for routine design office use. Thus γ is taken as 1·4 throughout instead of using a value dependent upon temperature and the air-fuel ratio. It is felt that such an assumption is valid when a designer wishes to investigate quickly the effects of changes in a number of variables rather than to carry out one calculation to a high degree of accuracy. Similarly the presence of reflected waves at the port during the generation of the primary wave is neglected since their inclusion would lead to a considerable complication of the calculations in determining the mode of behaviour of the ports, i.e., "partially open" or "closed." Experimental verification of the method described is as yet incomplete.

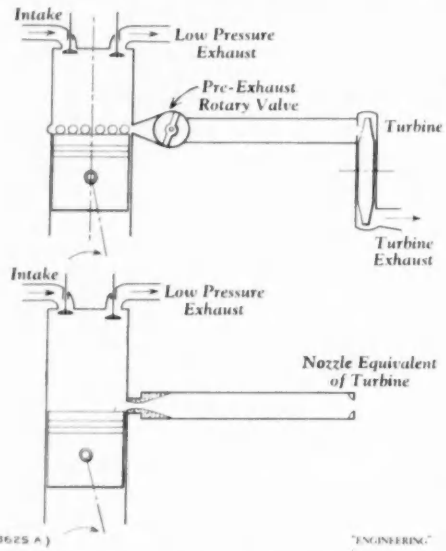


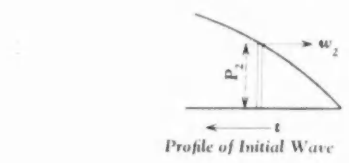
Fig. 1 Engine layout and physical equivalent.

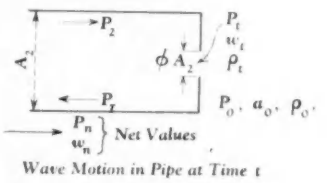
CALCULATION OF DISCHARGE PROCESS

As shown in Fig. 1 the engine with its port system, rotary valve, pipe and turbine may be considered to be physically equivalent to a cylinder discharging into a pipe through a *vena contracta* and sudden enlargement and the turbine may be replaced for the purposes of the discussion by a nozzle of known area ratio.

The formation of the fundamental pulse resulting from the discharge from a cylinder of volume V into a pipe of reduced cross-sectional area A_2 has been considered by Wallace and Mitchell[1] and also by Cole and Mills.[2] The graphical method of Cole and Mills is particularly convenient for the rapid determination of pulse shapes and the same nomenclature has been used in the following analysis.

With the amplitude of the pulse known, it remains to determine the amount of energy transported down the pipe and delivered to the turbine. For this purpose the turbine may be considered as equivalent to a nozzle as suggested by Jenny,[3] the ratio of the nozzle area to pipe area being ϕ. The influence of such a restriction upon the reflection and transmission of the pressure waves and the consequent distribution of energy will be considered.





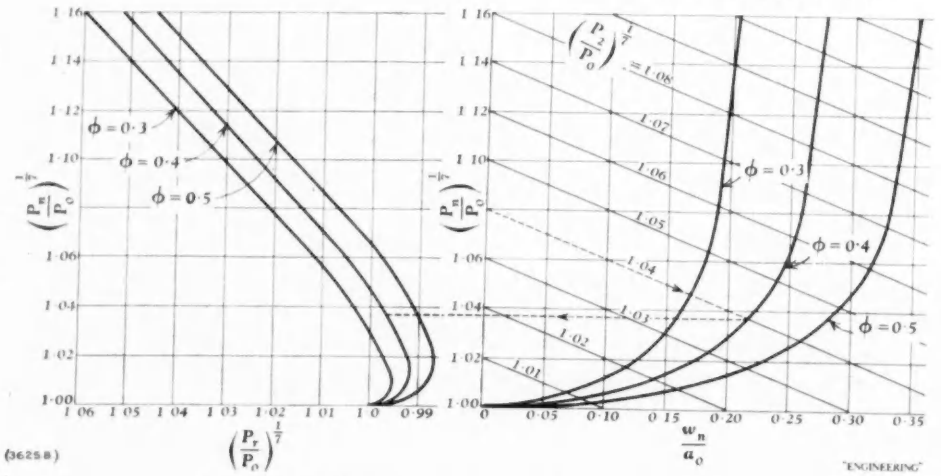


Fig. 2 Reflection and transmission of waves at constriction.

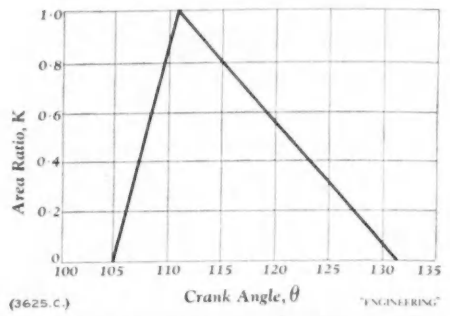


Fig. 3 Exhaust port area ratio plotted against crank angle.

EFFECT OF NOZZLE

The conditions obtaining in the pipe and nozzle at any time t are shown in the upper part of Fig. 2. It is assumed that there is a wave of known amplitude P_2 and velocity w_2 arriving at the nozzle, of an area ratio ϕ; there will then be generated a reflected wave P_r either positive or negative in sign depending upon the initial conditions. The conditions in the throat of the nozzle and at the turbine exhaust are denoted by the subscripts t and o respectively. The pressure P_n and velocity w_n, for use in the steady flow nozzle equations, resulting from the superimposition of the waves are obtained from the wave summation laws described by Bannister and Mucklow.[4]

Thus

$$\left(\frac{P_n}{P_0}\right)^{\frac{1}{7}} = \left(\frac{P_2}{P_0}\right)^{\frac{1}{7}} + \left(\frac{P_r}{P_0}\right)^{\frac{1}{7}} - 1 \quad . \quad (1)$$

and

$$\frac{w_n}{a_0} = 5\left[\left(\frac{P_2}{P_0}\right)^{\frac{1}{7}} - \left(\frac{P_r}{P_0}\right)^{\frac{1}{7}}\right] \quad . \quad . \quad (2)$$

$$= 5\left[2\left(\frac{P_2}{P_0}\right)^{\frac{1}{7}} - \left(\frac{P_n}{P_0}\right)^{\frac{1}{7}}\right] - 1 \quad (3)$$

The influence of the nozzle upon the mass flow may be conveniently analysed by means of the laws of isentropic flow as stated by St. Venant. For the subsonic range it may be assumed that the throat pressure P_t is equal to the back pressure P_0 and that $a_t = a_0$ and $\rho_t = \rho_0$. The temperature corresponding to a_0 and ρ_0 is that obtained by isentropic expansion from P_n, T_n to P_0 and is not that of ambient air at this pressure.

Energy equation from sections n to t:

$$\left(\frac{w_t}{a_0}\right)^2 - \left(\frac{w_n}{a_0}\right)^2 = \frac{2}{\gamma - 1}\left[\left(\frac{a_n}{a_0}\right)^2 - 1\right] \quad (4)$$

Continuity:

$$w_n \rho_n = \phi w_t \rho_t$$

and for isentropic flow

$$\frac{\rho_t}{\rho_n} = \left(\frac{a_0}{a_n}\right)^{\frac{2}{(\gamma-1)}} = \left(\frac{P_0}{P_n}\right)^{\frac{1}{\gamma}}$$

hence

$$\frac{w_t}{a_0} = \frac{w_n}{a_0}\,\frac{1}{\phi}\left(\frac{a_n}{a_0}\right)^{\frac{2}{(\gamma-1)}} \quad . \quad . \quad (5)$$

Inserting (5) in (4)

$$\left(\frac{w_n}{a_0}\right)^2 = \frac{\frac{2}{\gamma - 1}\left[\left(\frac{a_n}{a_0}\right)^2 - 1\right]}{\frac{1}{\phi^2}\left(\frac{a_n}{a_0}\right)^{\frac{4}{\gamma-1}} - 1} \quad . \quad . \quad (6)$$

or employing pressures,

$$\left(\frac{w_n}{a_0}\right)^2 = \frac{2}{\gamma - 1}\,\frac{\left\{\left[\left(\frac{P_n}{P_0}\right)^{\frac{(\gamma-1)}{2\gamma}}\right]^2 - 1\right\}}{\frac{1}{\phi^2}\left[\left(\frac{P_n}{P_0}\right)^{\frac{(\gamma-1)}{2\gamma}}\right]^{\frac{4}{(\gamma-1)}} - 1} \quad . \quad . \quad . \quad (7)$$

This equation describes the behaviour of the

gas in the nozzle up to the point where the gas particle velocity becomes sonic, i.e., the threshold is $w_t = a_t = a_0$. To determine the threshold state for given values of w_n, a_n and ϕ it is necessary to substitute $\frac{w_t}{a_0} = 1$ in equation (4)

$$\frac{2}{\gamma - 1}\left(\frac{a_n}{a_0}\right)^2 + \left(\frac{w_n}{a_0}\right)^2 = \frac{\gamma + 1}{\gamma - 1}. \quad (8)$$

The intersection of this ellipse with the curve defined by equation (6) gives the critical values. Thus for $\gamma = 1{\cdot}4$ equations (8) and (6) on combining become

$$6 - 5\left(\frac{a_n}{a_0}\right)^2_{crit.} = \frac{5\left[\left(\frac{a_n}{a_0}\right)^2_{crit.} - 1\right]}{\frac{1}{\phi^2}\left(\frac{a_n}{a_0}\right)^{10}_{crit.} - 1}. \quad (9)$$

The variation of $\frac{a_n}{a_0}$ with $\frac{w_n}{a_0}$ for various values of ϕ may be calculated according to equation (6) and the results plotted as in the right-hand quadrant of Fig. 2, the limit of the curves being

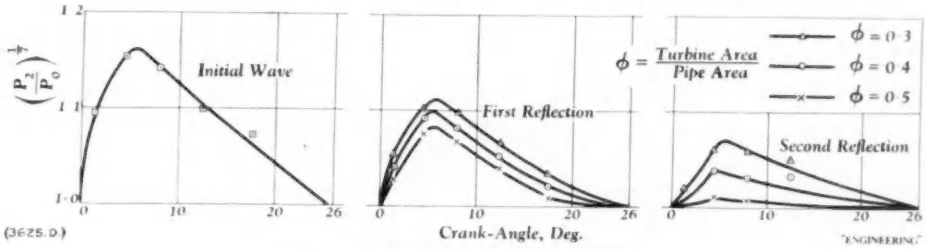


Fig. 4 Amplitude of incident pulses.

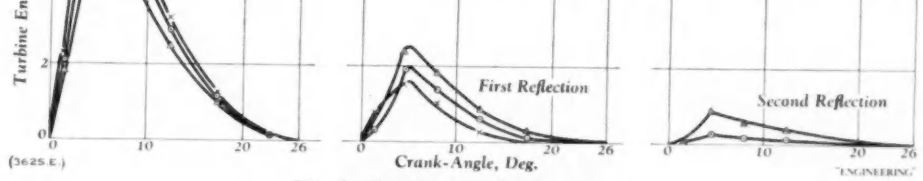


Fig. 5 Distribution of pulse energy.

defined by the critical values obtained from the sonic threshold equation (9).

For the sonic range it is known that $w_t = a_t$ and hence from the continuity equation,

$$w_n = \phi\, a_t \left(\frac{a_t}{a_n}\right)^{\frac{2}{\gamma-1}}$$

$$\frac{w_n}{a_0} = \phi\, \frac{a_n}{a_0}\left(\frac{a_t}{a_n}\right)^{\frac{\gamma+1}{\gamma-1}}. \quad . \quad (10)$$

For a given ϕ there exists a critical value of $\frac{a_t}{a_n} = \left(\frac{a_0}{a_n}\right)_{crit.}$, as given by equation (9), and substitution of this value in equation (10) gives a linear relationship between $\frac{w_n}{a_0}$ and $\frac{a_n}{a_0}$ for the sonic range.

Thus for $\gamma = 1{\cdot}4$,

$$\frac{w_n}{a_0} = \phi\, \frac{a_n}{a_0}\left(\frac{a_t}{a_0}\right)^6_{crit.}. \quad . \quad (11)$$

Fig. 2 may now be extended into the sonic range by making the appropriate substitutions in equation (11). The previous analysis is based on the assumption of steady flow through the nozzle. The transient nature of the phenomenon is considered by superimposing the constraint of the wave equations, that is,

$$\left(\frac{P_r}{P_0}\right)^{\frac{1}{7}} = \left(\frac{P_n}{P_0}\right)^{\frac{1}{7}} - \left(\frac{P_2}{P_0}\right)^{\frac{1}{7}} + 1 \quad . \quad (1)$$

Now $\left(\frac{P_2}{P_0}\right)^{\frac{1}{7}}$ has been determined from the discharge analysis, and it remains to calculate the manner in which this pulse is partially transmitted and reflected.

From equations (1) and (3) it will be seen that, for a given value of $\left(\frac{P_2}{P_0}\right)^{\frac{1}{7}}$, there exists a linear relationship between $\frac{w_n}{a_0}$ and $\left(\frac{P_n}{P_0}\right)^{\frac{1}{7}}$ and it is thus only necessary to determine the co-ordinates of two points in order to draw the line. For $\phi = 0$ (i.e. a closed end) there will be a total reflection hence

$$\frac{w_n}{a_0} = 0.$$

and

$$\left(\frac{P_n}{P_0}\right)^{\frac{1}{7}} = 2\left(\frac{P_2}{P_0}\right)^{\frac{1}{7}} - 1.$$

Thus for a given $\frac{P_2}{P_0}$ these equations define a point on the $\frac{P_n}{P_0}$ axis.

For $\phi = 1$ (i.e., an open end), $\frac{P_n}{P_0} = 1$ and

$$\frac{w_n}{a_0} = 10\left[\left(\frac{P_2}{P_0}\right)^{\frac{1}{7}} - 1\right]$$

thereby defininining a point on the $\frac{w_n}{a_0}$ axis.

These points are joined by a straight line and the process repeated for other values of $\frac{P_2}{P_0}$, Fig. 2 has thus a series of inclined lines intersecting the ϕ curves.

For a known ϕ the point of intersection gives the values of $\frac{P_n}{P_0}$ and $\frac{w_n}{a_0}$ associated with the given value of $\frac{P_2}{P_0}$. Since $\frac{P_2}{P_0}$ and $\frac{P_n}{P_0}$ are now known, we may construct, in another quadrant, curves relating $\frac{P_r}{P_0}$ and $\frac{P_n}{P_0}$ for various ϕ values according to equation (1). These reflected waves, if the rotary valve is closed, make a double traversal of the pipe, returning to the turbine as new values of $\frac{P_2}{P_0}$, and the process is repeated until the residual waves are negligible. Knowing the reflection and transmission which the initial pulse undergoes, it is now possible to determine the amount of energy which the transmitted part could impart to the turbine.

UTILISATION OF ENERGY IN TURBINE

By means of the chart* just described, it is possible to determine the variation of P_n and w_n with time, that is, the net conditions obtaining in the pipe. The process may be conveniently divided into the same time elements as employed in the mass discharge calculation, and the assumption made that mean conditions are operative over the whole interval.

The energy of the element is thus

$$E_n = \frac{G}{2g}\left(\frac{2\gamma}{\gamma - 1}\frac{g P_n}{\rho_n} + w_n^2\right)\Delta t \quad (12)$$

where G is the instantaneous mass flow $= A_2 w_n \gamma_n$ for a pipe area A_2.

Now

$$\frac{\gamma}{\gamma - 1}\frac{g P_n}{\rho_n} = 5 a_n^2 \quad \text{and} \quad \rho_n = \frac{\gamma g}{a_n^2} \times P_0\left(\frac{a_n}{a_0}\right)^7$$

hence

$$E_n = \frac{A_2}{2}\gamma a_0 P_0\left(\frac{w_n}{a_0}\right)\left(\frac{a_n}{a_0}\right)^5\left[5\left(\frac{a_n}{a_0}\right)^2 + \left(\frac{w_n}{a_0}\right)^2\right]\Delta t \quad . \quad . \quad . \quad (13)$$

Now the gases can be expanded to the turbine exhaust pressure and a temperature corresponding to the adiabatic expansion from P_n to P_0, so that the energy remaining is

$$E_b = \frac{G}{2g} 5 (a_0)^2 \Delta t.$$

Thus the energy drop available in the turbine is given by

$$E_n - E_b = \frac{A_2}{2}\gamma a_0 P_0\left(\frac{w_n}{a_0}\right)\left(\frac{a_n}{a_0}\right)^5 \left[5\left\{\left(\frac{a_n}{a_0}\right)^2 - 1\right\} + \left(\frac{w_n}{a_0}\right)^2\right]\Delta t \quad (14)$$

The total energy delivered to the turbine is then the sum of the energies of each small time element. The actual amount of energy utilised by the turbine is of course determined by the efficiency of the turbine itself, and from the latest information this may be taken as 70 per cent. for full periphery admission.

The wave trains are attenuated by friction as they traverse the exhaust manifold, and the reduction in pulse amplitude must be considered when calculating the energy available in an actual installation. Details are omitted of the manner in which the attenuation may be computed and the reader is referred to Mucklow and Wilson[5] and Wallace and Nassif[6] for further information on this subject.

FACTORS INFLUENCING THE BLOWDOWN PULSE ENERGY

When carrying out preliminary design calculations it is helpful to determine trends rather than exact values, and accordingly the effect of pipe friction can be neglected as a first approximation. Calculations based on the dimensions of the General Motors 71 engine and the pre-exhaust port diagram, as shown in Fig. 3, have been carried out to determine the influence of engine port area and operating speed upon the amount of available energy and the results will be reported at a later date. Similarly, the influence of the area of the pipe itself, that is, change in the value of K for a given port area, may be investigated and it has been found that

* The method of using the chart Fig. 2, is to follow the known $\left(\frac{P_2}{P_0}\right)^{\frac{1}{7}}$ line to intersect the given ϕ curve. Appropriate values of $\left(\frac{P_n}{P_0}\right)^{\frac{1}{7}}$ and $\left(\frac{w_n}{a_0}\right)$ are read off for use in the energy equation. The horizontal line from the point of intersection cuts the ϕ curve in the other quadrant to give the reflected wave amplitude $\left(\frac{P_r}{P_0}\right)^{\frac{1}{7}}$.

the available energy is a maximum when the maximum port area and the pipe area are equal, i.e., $K_{max.} = 1$. This conclusion is also found to be valid for the case when friction is considered, for the attenuation coefficients assumed, and accordingly the following calculations to determine the influence of turbine area upon available energy are made on the assumption that $K_{max.} = 1$. For a release pressure of five atmospheres, a release temperature of 2,000 deg. F. abs. and $K_{max.} = 1$ the pulse amplitudes are as shown in Fig. 4 for various ϕ values and the distribution of pulse energy is as in Fig. 5.

As is to be expected, more energy is transmitted in the first pulse for large ϕ values than with greater constrictions. At the same time, however, less energy is available for succeeding pulses and this may have an undesirable effect upon the turbine efficiency. Thus in applying this work to an actual installation it would be necessary to determine how the efficiency of an impulse turbine varies when subjected to one major pulse or to two or three smaller ones. It might well be that even with the influence of friction the latter course is preferable.

REFERENCES

[1] Wallace and Mitchell. "Wave Action Following the Sudden Release of Air Through an Engine Port System." *Proc.I.Mech.E.*, vol. 1B, No. 8, page 343, 1952-53.

[2] Cole and Mills. "The Theory of Sudden Enlargements Applied to the Poppet Exhaust Valve, with Special Reference to Exhaust-pulse Scavenging." *Proc.I.Mech.E.*, vol. 1B, No. 8, page 364, 1952-53.

[3] Jenny. *Berechnungen und Modellversuche über Druckwellen grosser Amplituden in Auspuff-Leitungen.* Ameba Druck, Basle, Switzerland.

[4] Bannister and Mucklow. "Wave Action Following Sudden Release of Compressed Gas from a Cylinder." *Proc.I.Mech.E.*, vol. 159, page 269, 1948.

[5] Mucklow and Wilson. "Wave-Action in Pipes: The Attenuation and Reflection of Compression Waves Propagated in Pipes." *Proc.I.Mech.E.*, vol. 169, No. 1, page 69, 1955.

[6] Wallace and Nassif. "The Effect of Friction on Compression and Rarefaction Waves of Finite Amplitude." ENGINEERING, vol. 175, page 674, 1953.

REDUCING ENGINE NOISE AT ASHFORD COMMON PUMPING STATION

ENCLOSURES FOR DIESEL-GENERATOR SETS

By A. J. King, M.SC.TECH., D.SC., M.I.E.E., F.INST.P.

The new pumping station of the Metropolitan Water Board at Ashford Common has a large hall containing engine-driven generators to provide emergency power for the pumps. Since it was expected that the engines would inevitably be somewhat noisy, sound-absorbent treatment of the ceiling and walls was introduced where possible to reduce the "build-up effect" which would otherwise increase the noise in the station compared with that which would be heard near the engines if they were operating in the open air. In spite of this treatment, which, it was estimated, would probably reduce the noise level by 5 to 10 db., the noise heard when the first Diesel-generator set was started was considered to be out of keeping with the very attractive design and layout of the station. The Board's chief engineer, Mr. H. F. Cronin, therefore consulted the Research Department of the Metropolitan-Vickers Electrical Company, Limited. When the first set was run, it was obvious that the noise of the alternator was unimportant compared with that of the engine. Since, in the present state of knowledge, there is little, if anything, that can be done to reduce the inherent noise of Diesel engines—there being, for instance, practically no change in loudness with load—the alternatives of enclosing the engines or of providing an enclosed observation gallery were considered. The provision of a gallery was found to be architecturally undesirable, so attention was given to the problem of designing suitable enclosures or "acoustic hoods" for the sets.

The engines of the sets to be enclosed are each of 1,700 h.p. with 16 cylinders and an operating speed of 750 r.p.m. Each is directly coupled to an alternator, the set being mounted on a massive concrete plinth passing through the main floor right down to the basement. Before the enclosures could be designed it was necessary to know the level and composition of the engine noise, and the level that was considered permissible. Measurements were therefore made with a portable sound-level meter and analyser at points near to the engine and also in an older type of pumping station at Kempton where the noise was considered tolerable. The total noise readings are given in Tables I and II and the noise analyses in Table III. The magnitudes of the component tones in the noise are given in Table III, in sound-pressure level in decibels above 0·0002 dyne per sq. cm., and in equivalent loudness in phons using the Churcher and King equal-loudness contours.[1] It is necessary to make this conversion of the physical magnitudes in db. into subjective values in phons in order to assess the relative importance of the components to the human ear.

It was also necessary to know the amount of structure-borne sound that would be conducted to the enclosure from the plinth, as this sets an upper limit to the noise attenuation that can be achieved by an enclosure. To reduce the conduction of vibration from the plinth to the main floor, a layer of Coresil had been included

TABLE I.—*Total Noise at Kempton Station*

Low speed vertical steam engines and geared turbine driven pumps in the basement

Position	Sound level, db.
Near station entrance, inside	87
,, vertical steam engine	88-90
,, steam turbine	87-88
,, turbine gears	94-95

half-way up the plinth and a gap left all round between the main floor and the plinth. To check the effectiveness of these measures, vibration measurements were made with a calibrated vibration pick-up, amplifier and analyser at points on the top of the plinth and on the main floor nearby. The results showed a steady increase in attenuation of vibration from 15 db. at 100 cycles per second to 25 db. at 1,000 cycles per second. In view of the increased effectiveness, from the point of view of the ear, of attenuations at 100 cycles compared with those at 1,000 cycles, it was considered that a noise attenuation by enclosure of the order of 25 db. was possible. However, it must be remembered that the enclosure of a source of noise tends to conserve the sound energy inside the enclosure, so raising the sound level by "build-up effect" and reducing the net attenuation achieved. Enclosure also necessitates reconsidering the cooling of the set.

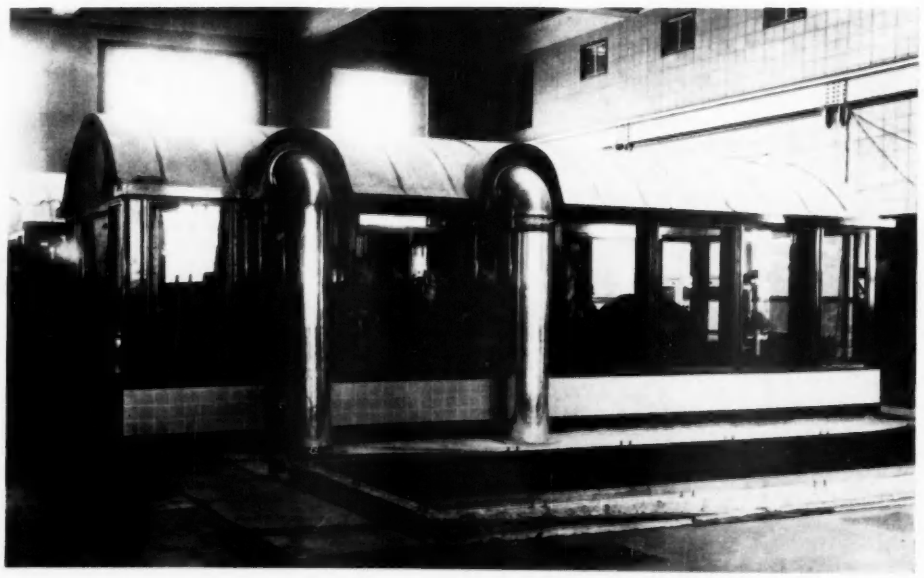
A further requirement of the enclosure was that it should have windows to permit a good view of the engine and generator from the outside. All these considerations were borne in mind in designing the enclosure shown in the accompanying illustration.

The sound level in the Kempton station which was considered as just satisfactory is seen from Table I to be approximately 88 db. while the corresponding mean figure for the new station, from Table II, is 102 db. The net attenuation of 14 db. was therefore the least that could be tolerated, and more attenuation was very desirable to justify the cost of enclosure. It was therefore decided to aim for a net attenuation of 25 db. The build-up effect in the enclosure should be kept down to 5 or 6 db. by providing sound-absorbent tiles where possible on the inside surface, so the gross attenuation required would be 30 db.

TABLE II.—*Total Noise at Ashford Common Station*

One Diesel-generator set, 750 r.p.m.

Position	Before enclosure, db.	After enclosure		Build-up, db.	Attenuation, db.
		Inside db.	Outside db.		
2 ft. from engine E side	106	111		5	
2 ft. from engine end	101	106		5	
2 ft. from exciter end	98	105		7	
5 ft. from engine E side	103		80		23
5 ft. from engine W side	104		82		22
30 ft. from engine W side	95		73		22



The engine enclosures for the Diesel-driven generator sets at Ashford Common pumping station provide a net attenuation of 22 db. The large windows have double panes, $\frac{1}{4}$ in. and $\frac{3}{8}$ in. thick, mounted 4 in. apart in separate resilient settings.

TABLE III.—Analyses of Engine Noise

Readings in open at 5 ft. from engine on E. side; when enclosed, at 2 ft. from engine and enclosure. Gross attenuation = Inside − Outside. Net attenuation = Open − Outside.

Frequency c/s	Sound pressure level, db					Equivalent loudness, phons					Source
	Open	Enclosed		Attenuation		Open	Enclosed		Attenuation		
		Inside	Outside	Gross	Net		Inside	Outside	Gross	Net	
25	84	85	68	17	16	54	55	0	55	54	Engine r.p.s. (2)
37	73	84	75	9	−2	38	63	42	21	−4	" " (3)
87	81	91	70	21	11	67	81	51	30	16	" " (7)
100	81	94	68	26	13	69	83	51	32	18	" " (8)
200	86	89	69	20	17	80	83	62	21	18	Firing (1)
300	92	103	70	33	22	87	96	67	29	20	—
400	89	92	67	25	22	85	88	65	23	20	" (2)
600	95	96	57	39	38	92	93	56	37	36	" (3)
1,000	83	89	59	30	24	83	89	59	30	24	" (5)
3,000	77	85	52•	33	25	82	91	63•	28	19	—
5,000	74	81	45•	36	29	73	80	42•	38	31	—
7,500	70	86	54•	32	16	57	76	39•	37	18	—

• Background noise

The attenuation of walls or enclosures in virtue of their mass is given approximately by the theoretical relation:

Attenuation (db.) = 20 log mf − 29 .. (1)

where m is the surface density of the wall in lb. per sq. ft. and f is the frequency of the sound in cycles per second. The attenuations obtained in practice are usually a few db. less than the theoretical values, so this was borne in mind in the following design. Reference to the engine-noise analysis in Table III suggests that the most important components to reduce in terms of phons are those of 600 and 300 cycles.

From equation (1) it follows that an attenuation of 30 db. at 300 cycles per second calls for a wall density of 3 lb. per sq. ft. There was no difficulty in providing at least this density in the dwarf walls and arched concrete roof of the enclosure and in the two doors. In the case of the windows, 3 lb. per sq. ft. corresponds to $\frac{1}{4}$ in. plate glass. However, in view of the large panels of glass necessary to give adequate visibility of the set and the possibility of reduced attenuations at particular frequencies due to resonances of the panels, or to their behaving at low frequencies in virtue of their stiffness rather than their density, it was decided to use double panels, one of $\frac{1}{4}$ in. and the other of $\frac{3}{8}$ in. By keeping them at least 4 in. apart[2] in separate resilient settings, the coupling between them should be low enough for their attenuations to be to some extent additive and having different thicknesses and resonant frequencies the combined result should be free from serious minima.

As a check on the calculations in terms of sound level in db. it is possible to estimate the reduction in equivalent loudness in phons for a given noise spectrum, knowing the law of summation of the human ear. The method, which has been described,[3] involves converting sound levels in db. into equivalent loudness in phons,[1] summing these phon values by the ear-summation curve and quoting the sum in phons. If this process is applied before and after each component has been attenuated by an amount appropriate to its frequency, the difference between the two sums gives the attenuation in phons. This simple method is accurate only when the noise spectrum consists of discrete tones whereas in the present case there was a background of noise distributed over the whole audio-frequency range. To reduce build-up effect inside the enclosure, the arched concrete roof was lined with sound-absorbent tiles.

As the enclosure was virtually air-sealed, a correctly controlled air supply had to be introduced to dissipate the heat build-up from both engine and alternator. It was found by the engineers concerned that the quantity of air required to control the temperature rise in the alternator agreed fairly closely with the amount required to aspirate the engine through its blower, namely 5,600 cub. ft. per min. A design was therefore adopted by which outside air was admitted to the building through an air shaft which incorporated a fan chamber.

To prevent the engine blower from being overloaded by the resistance of any additional ducting, axial-flow fans delivered the air through ductwork from the shaft into the enclosure terminating in a filter and diffuser over the alternator end of the enclosure. The cool air is initially circulated through the windings by the rotor fans and subsequently drawn across into the engine-blower intake.

In order to relieve the enclosure of any pressure, either positive or negative, caused by running the engine without the fan or vice versa, balanced aluminium louvres, half of which open inwards and half outwards, were fitted in the cable-entry opening which connects the enclosure with the basement.

To minimise the emission of sound through the louvres, a splitter-type silencer was installed in the framework, and at the air-inlet end of the duct, absorption-type silencers were fitted to the fans. J. Dale, Limited, Southgate, were responsible for the design and construction of these silencers and for the detail design and construction of the enclosures.

The twin exhaust pipes had to be taken through the enclosure with resilient seals and then passed down into the basement where a proprietary silencer and waste-heat boilers are installed, the outlet pipes passing outside the building. The exhaust pipes were heavily lagged to cut down noise emission and had an outer covering of polished sheet aluminium.

Table II gives the results of total noise measurements both before and after enclosure. The build-up effect is seen to amount to approximately 6 db. and the net attenuation to 22 db., making the gross attenuation of the enclosure 28 db. These figures are in good agreement with the design values. Table III shows the variation in the attenuation with frequency, both in db. and phons. The three sets of readings, in the open and inside and outside the enclosure, are not all strictly comparable as they were not all taken in the same place, so variations of 2 db. are not always significant. However, it is clear that both the build-up effect and attenuation vary widely with frequency, especially the former which rose to as much as 16 db. at one frequency, probably due to resonance of the enclosure.

The appearance of the enclosures is very pleasing, the polished wood framework, large clear plate-glass windows and coloured tiles combining to give a result which is aesthetically attractive as well as acoustically effective.

The author acknowledges with thanks the help of Mr. A. S. Ennis who carried out the noise and vibration measurements and assisted in the design. He wishes to express his thanks to Mr. F. Wood, M.I.C.E., mechanical engineer to the Water Board, for his kindness in arranging for the tests, for providing the photograph and for allowing the results to be published. He is also indebted to Dr. Willis Jackson, F.R.S., M.I.E.E., Director of Research and Education Departments, and to Mr. B. G. Churcher, M.Sc., M.I.E.E., Manager, Research Department, Metropolitan-Vickers Electrical Company, Limited, for permission to publish this article.

Bibliography

[1] B. G. Churcher and A. J. King, "The Performance of Noise Meters in Terms of the Primary Standard". *J.I.E.E.*, Vol. 81, No. 487, p. 80. (July 1937).

[2] J. E. R. Constable and G. H. Aston "Sound insulation of single and complex partitions". *Phil. Mag. Ser.* 7, Vol. XXIII, p. 161 (January 1937).

[3] A. J. King, "The reduction of structure borne sound by vibration attenuating supports". ENGINEERING (July 29 and Aug. 12, 1938).

★ ★ ★

CHECKING SECONDARY LIGHT STANDARDS

Comparisons at the N.P.L.

For the first time in 20 years, the secondary standards held by the Light Division of the National Physical Laboratory have been compared with the internationally agreed primary standard light source. These secondary standards are special tugsten-filament vacuum lamps and it is in terms of their intensity that the practical unit of light is maintained in this country.

The international standard is a small ceramic tube, or cavity radiator, immersed in a crucible full of pure platinum. The platinum is melted by high-frequency induction heating and then allowed to cool slowly. For the short period during which solidification is taking place the temperature remains stationary at the freezing point of platinum and the observations are made during this period. The interior of the small tubular radiator then has, by definition, a brightness (luminance) of 60 candelas per sq. cm. The recent observations were made by the latest precise photo-electric methods and it is of interest to note that although, as previously mentioned, the N.P.L. lamps have not been compared with the standard since they were first calibrated 20 years ago the values now found for their intensity agree with those previously obtained to within 0·5 per cent.

At present no adjustment in the N.P.L. photometric standards or calibrations is intended. A comparison with the results of other countries is, however, now in progress at the International Bureau of Weights and Measures and should any significant adjustment be thought proper in the light of these results it will be formally announced in the Laboratory.

★ ★ ★

CARRIER TELEPHONY FOR EIRE

Through Dialling Throughout

The autumn of last year saw the completion of the Irish national telephone network of underground cables. The network links Limerick, Cork, Waterford, Dundalk, Sligo, and Athlone, to Dublin. Many other towns are taken in *en route* and, at selected stations, facilities are provided to extend the service. Through dialling by the telephone operators to all parts of the network is possible.

Work on the project started early in 1950. The initial stages were equipped with two-tube coaxial cables and formed a 2·6 Mc/s carrier telephone network which provided an ultimate capacity of 600 two-way circuits. Advances in techniques permitted the use of a 4 Mc/s multi-circuit system for the final stage—Dublin to Sligo and Athlone—so that, should the need arise, a capacity of 960 circuits is available. In all the stages of the network, screened circuits with associated high-quality repeater equipment have been provided for the interchange of broadcast programmes. These circuits were laid up in the cable in addition to the coaxial tubes, and in some sections further conductors laid up in the cable provided for voice frequency circuits at the smaller towns which do not warrant direct access to the main coaxial system.

The contracts for the supply and installation of the coaxial cable and associated carrier telephone and power equipment were awarded to Standard Telephones and Cables Limited through their Dublin office.

STRESS RAISING EFFECTS OF HOLES IN WEB PLATES

DESIGN CHART PLOTTED

By H. G. Edmunds, PH.D.*

The stress concentration due to pure uniform bending around a hole that is offset from the neutral axis of a flat plate, Fig. 1, is analysed by combining the two known solutions for simple uniform tension and for pure uniform bending. The results of a photoelastic investigation of the problem are also presented.

If an infinite flat plate having a circular hole of radius a be subjected to uniform tension, as shown in Fig. 2:—

$$\underset{x \to \pm \infty}{\sigma_x} = \text{const.} = A,$$

it may be shown† that the largest stresses are the tangential stresses at the hole and that they are given by:—

$$\underset{r=a}{\sigma_\theta} = A(1 - 2\cos 2\theta) \quad . \quad (1)$$

If, on the other hand, the plate be subjected to pure uniform bending by the application of the stress, as shown in Fig. 3, then:—

$$\underset{x \to \pm \infty}{\sigma_x} = B\,y$$

where B is a constant, and it may be shown‡ that the tangential stresses at the hole are given by:—

$$\underset{r=a}{\sigma_\theta} = 2Ba \sin\theta\,(2\sin^2\theta - 1) \quad (2)$$

In so far as these results hold for a plate of finite depth they may be used to determine the stresses due to pure uniform bending around a hole which is offset from the neutral axis of the plate. Thus, referring to Fig. 4, a bending moment, M, is related to the stress by:—

$$\underset{x \to \pm \infty}{\sigma_x} = \frac{M}{I}(e + y)$$

where I is the second moment of area of transverse cross-sections of the plate, and $\left(\frac{M}{I}\right)$ is constant. Substituting from equations (1) and (2) in order to determine the corresponding value of tangential stress at the hole:—

$$\underset{r=a}{\sigma_\theta} = \left(\frac{M}{I}\right)\{e(1 - 2\cos 2\theta) + 2a\sin\theta\,(2\sin^2\theta - 1)\}.$$

The largest maximum value of σ_θ occurs at Z where $\theta = \frac{\pi}{2}$, and it is:—

$$\underset{r=a;\ \theta=\frac{\pi}{2}}{\sigma_\theta} = \sigma_z = \left(\frac{M}{I}\right)(3e + 2a).$$

Therefore

$$f = \frac{\sigma_z}{\frac{M\,b}{I}} = 3\left(\frac{e}{b}\right) + 2\left(\frac{a}{b}\right). \quad . \quad (3)$$

The denominator, $\frac{M\,b}{I}$, is the greatest stress in the parent plate due to the bending moment, M, and thus f describes the greatest stress at the hole as a multiple of the greatest stress in the plate without the hole. The relationship between f and the ratios $\frac{a}{b}$ and $\frac{e}{b}$ described by equation (3) is represented graphically in Fig. 5. However, the theory is strictly valid only when both a and e are indefinitely small compared with b, so it is to be expected that the graph of the actual relationship between f and $\frac{a}{b}$ and $\frac{e}{b}$ will be a distorted form of Fig. 5, and the greater the values of the geometrical ratios, the greater the distortion.

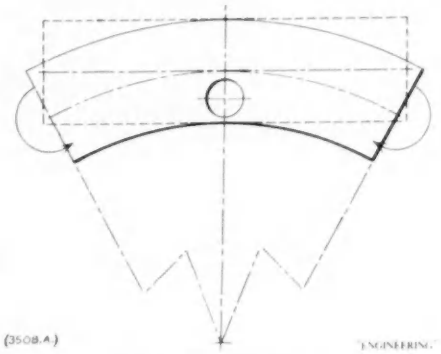


Fig. 1 The problem.

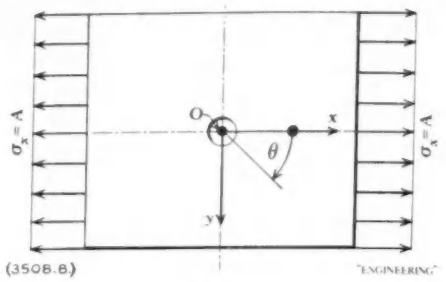


Fig. 2

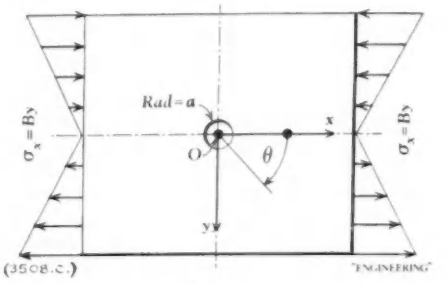


Fig. 3

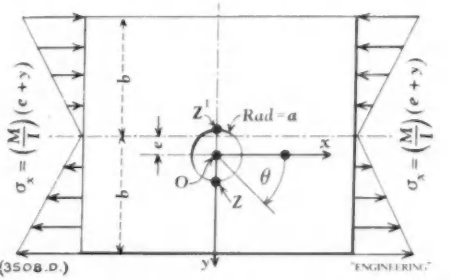


Fig. 4

Figs. 2, 3 and 4 The maximum stress in a flat plate, which resists a bending moment in its own plane and has a hole off-set from the neutral axis, can be determined by combining the concentrated stress due to pure tension (Fig. 2) with the concentrated stress due to pure bending when the hole is on the neutral axis (Fig. 3). The general condition is depicted in Fig. 4.

PHOTO-ELASTIC TESTS

An experimental investigation of the problem was made photo-elastically. Models of C.R. 39 were subjected to symmetrical four-point loading, and a compensator was used to measure the stress-optic effect at Z, and at Z_1 the point diametrically opposite. Readings were taken at a number of loads and the retardation was determined from the slope of a graph of compensator reading against load. After a first test, each model was inverted and tested again so as to alter the sense of the bending moment. By taking the mean of the two results, errors due to lateral contractions and to faulty loading arrangements were eliminated. Each model was calibrated by measuring the variation with load of the difference in stress-optic effect between two gauge marks scratched on the model. In the event, however, a single average value of the

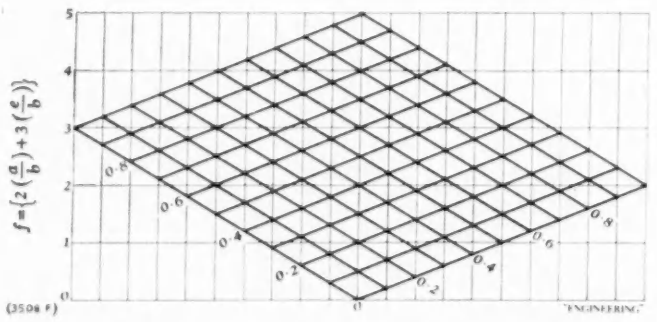


Fig. 5 The theoretical stress-raising factor, f, due to the combined conditions is shown above in terms of the geometry of the problem, as defined in Fig. 4. The analysis assumes the plate to be infinitely large with respect to the radius and off-set of the hole.

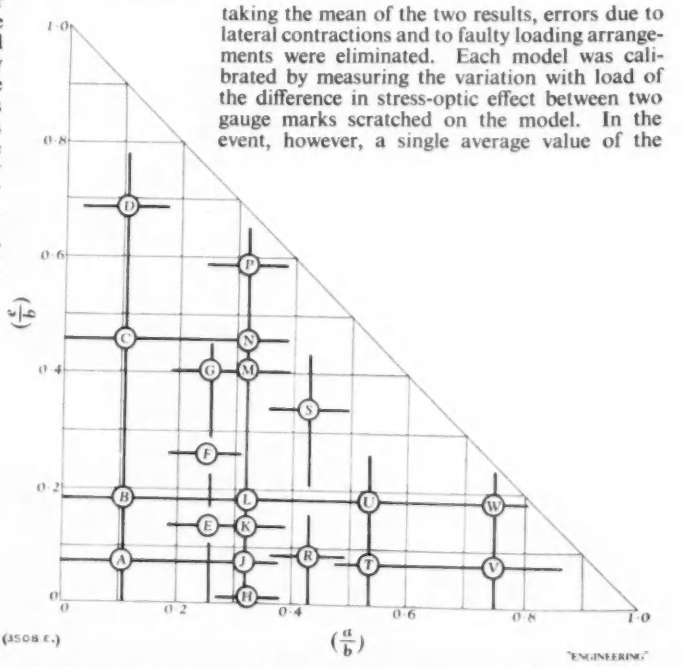
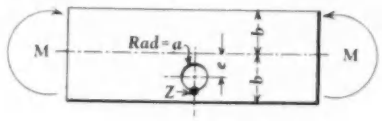


Fig. 6 Confirmation of the analysis was obtained photo-elastically, using 20 specimens. The geometry of the test-pieces is represented on this graph.

* Formerly of the Department of Engineering, University of Manchester, where this study was undertaken. Now at the Mechanical Engineering Laboratory, English Electric Company, Limited, Leicester.

† G. Kirsch, v.*d.i.*, vol. 42, 1898.

‡ Z. Tuzi, *Phil. Mag.*, Feb., 1930, page 210.



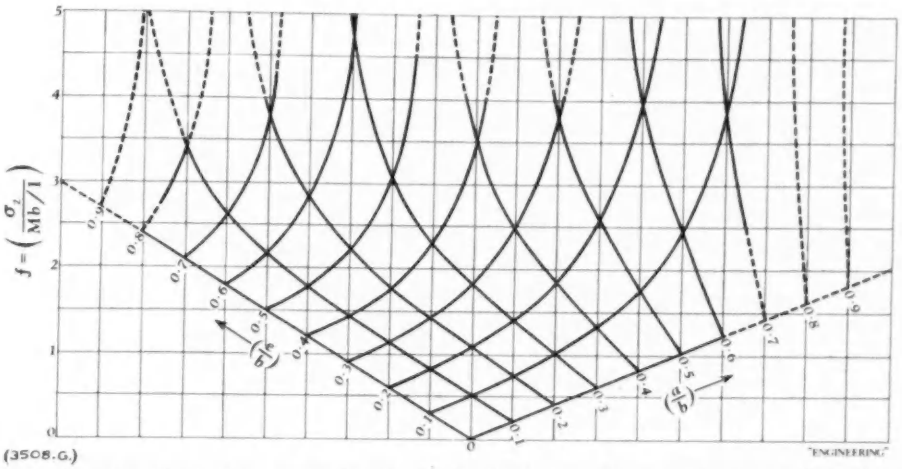


Fig. 7 The stress factor f, as measured experimentally, has been used to trace these curves in the form of a design chart. The curves should be compared to the theoretical relationships shown in Fig. 5.

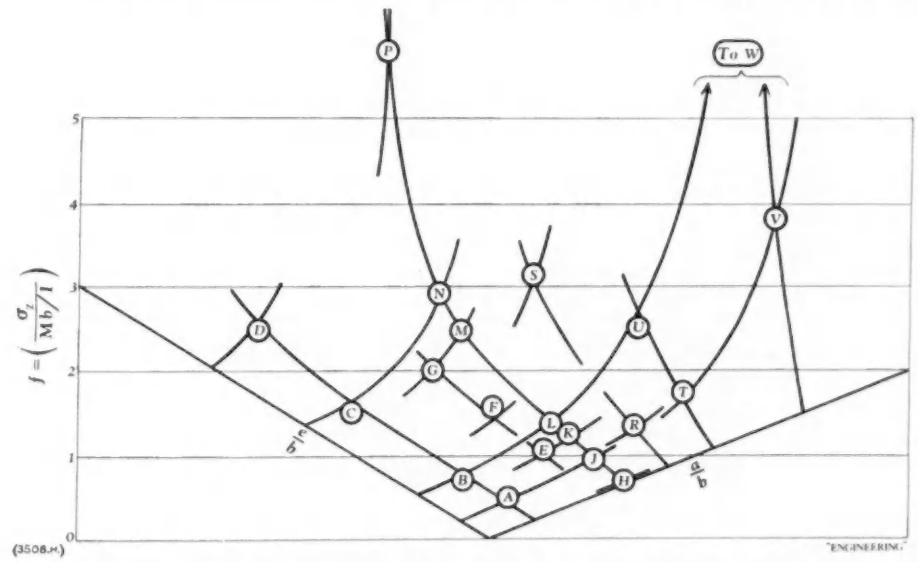


Fig. 8 The curves shown here have been extracted from Fig. 7 according to the dimensions of the models. The intersections of the curves should be compared with the centres of the circles which are plots of the values obtained experimentally; the close agreement indicates the reliance that can be placed on Fig. 7 as a design chart.

TABLE. *Experimental Results*
For all models $b = 0{\cdot}470$ in.

Legend	$\frac{a}{b}$	$\frac{e}{b}$	$\frac{\sigma_g}{\left(\frac{M\,b}{I}\right)}$	$\frac{\sigma_{z_1}}{\left(\frac{M\,b}{I}\right)}$
A	0·107	0·072	0·51	0
B	0·107	0·181	0·69	0·24
C	0·107	0·453	1·49	1·00
D	0·107	0·682	2·44	—
E	0·255	0·132	1·08	—0·08
F	0·255	0·255	1·57	0·38
G	0·255	0·402	2·00	0·87
H	0·32	0·009	0·69	—0·66
J	0·32	0·072	0·95	—0·41
K	0·32	0·132	1·25	—0·21
L	0·32	0·181	1·38	—0·04
M	0·32	0·402	2·48	0·76
N	0·32	0·453	2·92	1·04
P	0·32	0·583	5·79	—
R	0·425	0·085	1·35	—0·65
S	0·425	0·334	3·14	0·48
T	0·53	0·072	1·76	—0·82
U	0·53	0·181	2·49	—0·24
V	0·745	0·072	3·82	—1·70
W	0·745	0·181	9·75	—0·45

calibration was applied to all models because the differences in the observed values were considered not to be significant.

The essential details and results of the tests are listed in the Table; a graphical representation of the geometrical properties of the models tested is given in Fig. 6. Each test is represented by a circle, the co-ordinates of the centre of which indicate the values of $\frac{a}{b}$ and $\frac{e}{b}$. Assuming that the hole must not break through the edge of the plate, the limits of the possible geometry are set by the inclined line.

CARPET PLOT

Fig. 7—a carpet plot—is a graphical interpretation of the results in the form of a design chart where $f = \frac{\sigma_z}{\frac{M\,b}{I}}$ is plotted against $\frac{a}{b}$ and $\frac{e}{b}$ and it should be compared with the representation of the theoretical analysis given in Fig. 5. Since the tests were done at more or less irregular values of the parameters, Fig. 6 had to be completed by trial and error. As a design chart it has had to be presented in the form of curves for cardinal values of $\frac{a}{b}$ and $\frac{e}{b}$ and thus it is not possible on this figure to indicate the agreement

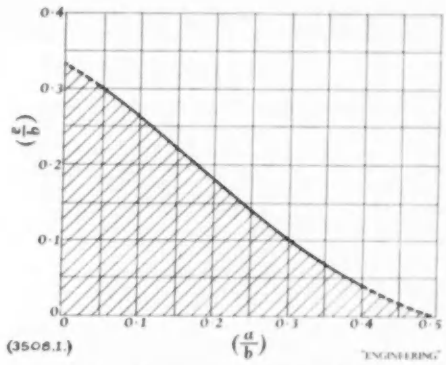


Fig. 9 When the geometry of the drilled plate can be represented by a point within the shaded area, the maximum stress occurring at the edge of the hole is less than the greatest bending stress in the parent plate.

obtained between these curves and the values determined experimentally. In tracing the curves of Fig. 6 three stringent conditions had to be satisfied, as follows:—

1. Each set of curves must be a "family" and must be smooth.
2. Every intersection of the families must lie on known ordinates defined by the values of the parameters of the intersecting curves.
3. Within experimental error, the curves must agree with the experimental data.

A comparison of Fig. 7 with the experimental results is made in Fig. 8. The arcs of curves have been extracted from Fig. 6 according to the geometry of the models. Their intersections define values of f which may be compared with the corresponding experimental values indicated by the centres of the circles. The legend used in Figs. 6 and 8 serves to identify the tests in the Table.

Fig. 9 has been extracted from Fig. 7. When the geometry of a plate may be represented by a point within the shaded area, that is to say, the ratios $\frac{e}{b}$ and $\frac{a}{b}$ are mutually less than the values indicated, then the concentrated stress at the hole does not exceed the greatest bending stress in the parent plate.

★ ★ ★

TACHOMETER USING POLYPHASE ALTERNATING CURRENT

The measurement of speed of rotation is often an important operation, both in schemes of instrumentation and in servo-mechanism techniques. A dynamo feeding a voltmeter is one method that is quite popular, but the presence of brushes is a disadvantage on account of the wear and friction losses caused. These difficulties are overcome by the alternating-current tachometer-generator recently introduced by Crompton Parkinson Limited, Crompton House, Aldwych, London, W.C.2.

A miniature alternator, employing a permanent magnet for its rotor, provides a three-phase voltage proportional to speed of rotation, and a moving-coil voltmeter with a rectifier is used to indicate the value of the voltage. The rectification of the polyphase output results in a much smoother meter voltage than is obtainable from a single-phase output, and because of this the indicator is steady at comparatively slow speeds. The permanent magnet is screened by the stator from external magnetic fields and is claimed to have a very stable characteristic; the generator can be short-circuited at 3,000 r.p.m. without changing the strength of the magnet by more than 0·1 per cent.

The generator has a nominal phase voltage of 17·40 volts per 1,000 r.p.m. for a resistive load of 4,600 ohms, or 17·81 volts for a load of 13,800 ohms. The accuracy of the system is said to be within one per cent. of full-scale deflection, at any part of the scale.

HIGH-INTENSITY COMBUSTION

LIMITATIONS OF EXISTING CHAMBERS

In a paper presented to the Institution of Chemical Engineers by Mr. R. P. Fraser, of the Imperial College of Science and Technology, South Kensington, on December 4, the significance and advantage of burning fuels at high rates of volumetric heat release were discussed. Extracts from the paper are given below.

High velocity, high temperature gaseous jets are readily produced by the combustion of fuel gases with air or oxygen, and the development of combustion apparatus to burn gaseous fuels at high rates has therefore been common. Only recently has attention been given to the burning of distillates and residual fuels under high intensity conditions as in the jet aero engine.

It is of interest to discover the maximum possible rate of burning in various designs of combustion chamber. Attempts are also being made to determine the maximum possible heat-release rates with liquid fuels under nearly ideal experimental conditions. From these determinations it is immediately found that even the most advanced practical equipment has, as yet, only reached a small fraction of the possible space heat-release rate. Needless to say, conditions of utility and life of equipment impose strict limitations on the burning rate that can be employed in commercial equipment.

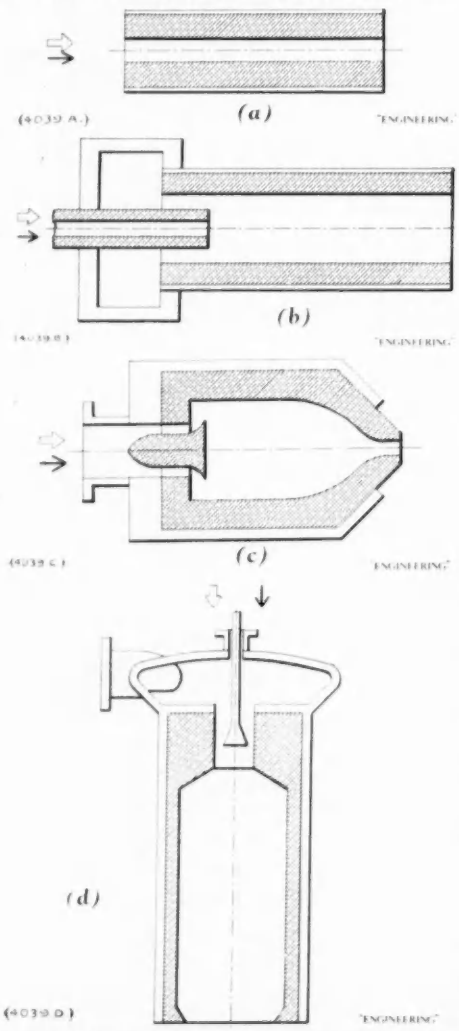


Fig. 1 Some examples of combustion chambers using gaseous fuel, designed to give high heat-release rates.

- **(a) Simplest ram jet apparatus for gaseous fuels.**
- **(b) Pulsating combustion with high heat-release rate.**
- **(c) High velocity with gaseous fuel.**
- **(d) Partially-submerged burner for town's gas and air mixture.**

High combustion rates depend upon combustion occurring at high temperature. Whereas in theory a fuel-oil flame can attain a temperature of 2,100 deg. C. without pre-heated air, in industrial furnaces the highest observed figure without pre-heat is only about 1,700 deg. C., and with pre-heat about 2,000 deg. C. With the exception of those industrial gases which are diluted with nitrogen, such as producer gas and blast-furnace gas, the theoretical flame temperatures at stoichiometric proportions are nearly the same for all industrial fuels. The potential maximum rate of burning with these fuels, therefore, does not vary greatly. Experiments in an almost ideal reactor carried out by Longwell and Weiss showed the importance of heat losses in practical combustion devices, and the experimenters estimate a reduction in the maximum heat release-rate of 30 per cent. for a heat loss of only 5 per cent. In the case of fuel in suspension in the form of particles, the complex nature of the dependance of the volumetric heat-release rate on the physical and geometrical character of the burning mixture is obvious. Large particles moving at a low velocity relative to the air will have only limited contact with oxygen. Because of their large mass, such particles plus their gas envelopes occupy only a small fraction of the mixture volume. To obtain a large interface between fuel and oxygen requires that the fuel particles be very small. One of the relations which still requires determination is that which shows how the heat-release rate depends on the mean size.

In most high-speed combustion chambers for transport devices, the walls are metallic and they thus have to be maintained at temperatures well below that of the flame. The heat absorption of such walls necessarily has a detrimental effect on the rate of burning by cooling the flame. Where the chamber can be lined with a ceramic of sufficient quality to attain the flame temperature and restrict chemical corrosion, heat losses are reduced and the hot walls can stabilise combustion at much higher mass velocities without blowing out, and thus much greater combustion intensity can be maintained. The mechanism of the combustion under these conditions in even simple cylindrical chambers is not yet fully understood.

A comparison of the maximum heat-release rates of many types of combustion equipment employing both gas and liquid fuels shows that common commercial apparatus never exceeds half a million B.Th.U. per cub. ft. per hour, and even large power station boilers operate at a figure of 0·025 to 0·03 million B.Th.U. per cub. ft. per hour. It is only where conversion space is important that figures approaching half a million are utilised. At the other end of the scale the typical liquid-fuel rocket, such as the V2 of the last war, achieved a figure of 175 million B.Th.U. per cub. ft. per hour. A surprising figure is that of 4·6 million B.Th.U. per cub. ft. per hour attained by the flame of an ordinary candle.

COMBUSTION CHAMBER DESIGN

It is possible to classify industrial equipment in several ways: by the way they function; by the fuel used; or by the purpose for which they are employed. According to purpose there are a number of characteristic uses, falling into two main headings: those devices in which emphasis is put on exhaust jet velocity, where the high speed in the gas stream gives faster convective heating; and those in which emphasis is put upon gaseous product composition, where the combustion process is closely controlled to determine the chemical composition of the products. The first are generally referred to as thermal jet burners and the second as high intensity or high duty combustion chambers.

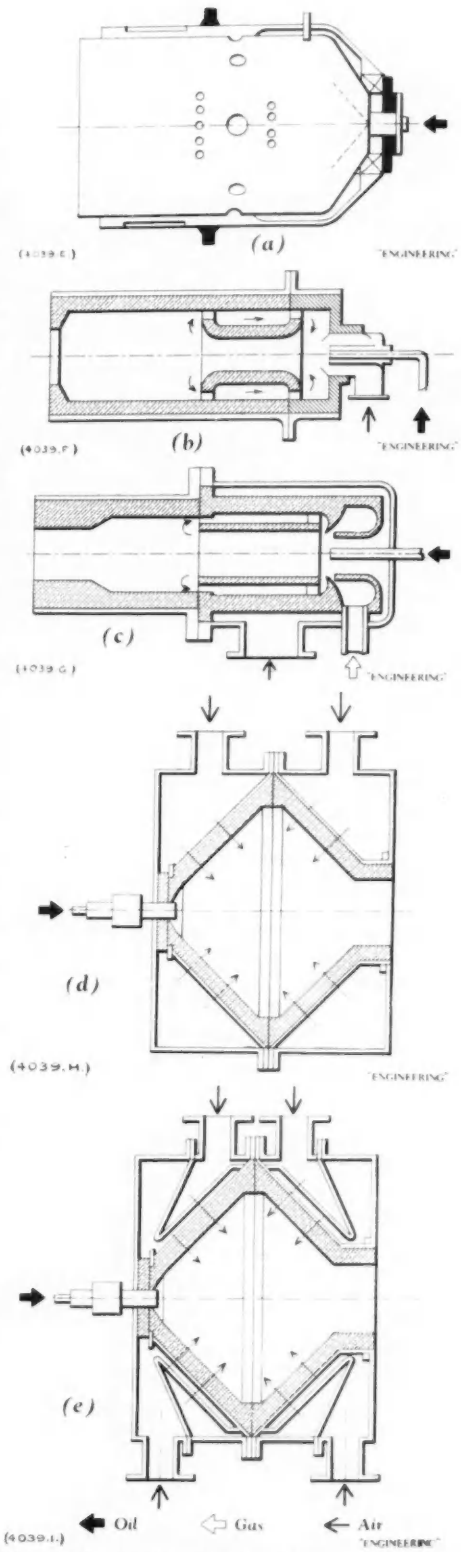


Fig. 2 Combustion chambers for liquid fuels. The advantages and limitations of these different examples are discussed in the text.

- **(a) " Jet can " for aero gas-turbines.**
- **(b) Chamber with space for atomisation from Venturi walls.**
- **(c) Arrangement for both liquid and gaseous fuels.**
- **(d) Combustion space with hollow cone of spray.**
- **(e) Hollow spray cone with separate zones of secondary air.**

Fig. 1a depicts the simplest form of apparatus using gaseous fuel; in some cases this may be a plain metallic tube such as is employed in ram jet

devices. When used in this way at high mass velocities, efficient combustion can only be maintained by the use of some form of flame holder or stabiliser. For the highest mass flows and lowest drag the tube should be refractory lined, in which case no flame holder is required. In the construction shown in Fig. 1b, pulsating or vibratory combustion can be set up. which, according to the tube length and diameter, may have frequencies between 1,000 and 2,000 cycles per second. Heat-release rates as high as 100 million B.Th.U. per cub. ft. per hour have been reported.

Where it is important that the exit nozzle should be shaped to form a jet to suit a particular manner of application, and where the combustion chamber pressure is required to be raised to obtain high jet velocity, an apparatus of the type of Fig. 1c may be employed, where a stoichiometric mixture issues from the diffuser into a compact ceramic-lined chamber from which the products issue as a jet from a narrow slot. An apparatus of this type, using methane and air and discharging to atmosphere from a chamber pressure of 2½ lb. per sq. in. can produce a gas velocity of about 1,400 ft. per second.

Combustion chambers for use in the submerged heating of liquids represent one of the earliest applications of high intensity combustion to chemical engineering. The advantages of this method are the very rapid transmission of heat to the liquid and the high heat-release rate which yield small-size combustion equipment. Although 30 million B.Th.U. per cub. ft. per hour in small gas burners is practicable, the temperature is too high for continuous running in larger plants, and these are usually designed for 7 million B.Th.U. per cub. ft. per hr. Fig. 1d shows a Swindon type combustion chamber designed for pre-mixed town's gas/air, and partial submersion.

When using liquid fuel, the combustion apparatus becomes more complex and the rate of combustion will be largely determined by the time occupied in the preparation of the fuel. The processes involved are (i) atomisation, (ii) volatilisation, and (iii) mixing with air. Each of these successive processes requires time and space within apparatus which, in some cases, may be divided into two parts: the fuel preparation area and the combustion space proper. In other apparatus these areas are combined all within one combustion chamber. Such equipments employ light distillate fuels or intermediate grades of residual fuel oils. Figs. 2a, b and c are of the first kind, and 2d and e are of the second. In b and c space is provided for atomisation and vaporisation of the fuel droplets from the wall of a vaporising tube or Venturi and also space for re-circulation of some of the products of combustion from the flame's zone rearwardly to mix with the incoming atomised fuel for the purpose of aiding vaporisation and combustion. Types a, b and c are usually employed where higher jet speeds are required for convective heating. On the other hand, d and e are the more useful where the combustion process has to be closely controlled to a definite chemical composition of products. Type 2e is particularly useful for obtaining controlled process atmospheres, where, for example, the quantity of oxygen in the atmosphere may not exceed a variation of ± 1 per cent., after making allowance for changes in product throughput and the admission of air through small leakages.

CONCLUSIONS

The large number of applications already found for combustion apparatus burning gases and liquid fuels at high volumetric rates, is evidence of a trend away from the large refractory brick-lined furnace as a heat source. In chemical plants the latter usually occupy valuable ground floor space, and repairs are costly in time and productivity. The compactness, lightness and mobility of high intensity burners allows the heat to be applied directly to the object to be heated, or to be mounted in continuity with ducting or upon the walls of a reaction process vessel. Although the amount of energy required to operate high velocity thermal jets is comparatively large, and more costly auxiliaries have to be employed, the capital cost of the complete plant is usually less, due to the smaller quantity of material and refractory employed in the combustion device itself. A major problem in fast thermal reaction research has been to devise techniques for starting, controlling and studying chemical reactions while in progress.

HOLME MOSS VERY-HIGH-FREQUENCY STATION

Frequency Modulation Extended to Wide Area

The very high frequency transmitting station of the British Broadcasting Corporation at Holme Moss, near Huddersfield, at which regular operation was inaugurated on December 10 is the first of its type to be opened in a permanent form with a full three-programme service. It is intended to provide satisfactory reception in Yorkshire, with the exception of parts of the North Riding; in Lancashire, as far north as Morecambe Bay; in Lincolnshire, with the exception of the extreme eastern and southern parts; and in Cheshire, Derbyshire, Nottinghamshire, north Leicestershire, north Shropshire, most of Staffordshire, the north-eastern part of Anglesey and Flintshire, and most of Derbyshire. In all, a further 14 million people will be able to take advantage of the new service. The transmission is horizontally polarised and is operated on the following frequencies: North of England Home Service 93·7 megacycles, Light Programme 89·3 megacycles and Third Programme 91·5 megacycles. The effective radiated power on each programme is 120 kW.

TRANSMITTER DESIGN

The six 10 kW very-high-frequency transmitters, of which there are two for each service, have been provided by Marconi's Wireless Telegraph Company, Limited, Chelmsford, and are installed in an extension to the existing television station building. They utilise the FMQ frequency modulation system which consists essentially of a quartz crystal oscillator. This oscillator is connected through a quarter-wave network to a balanced modulator, the susceptance of which is varied by the modulating signal, the latter in turn varying the frequency generated by the oscillator. The crystal has been specially cut so that the generation of spurious frequencies within the operating range is avoided. It is claimed that as a result the circuits are simple and are also reliable and easy to maintain. The output of the oscillator is multiplied by three stages of frequency doubling and one tripling stage to produce the required carrier frequency.

There are five stages of carrier frequency amplification the first two being of the conventional push-pull type, while the remaining three are single-ended earthed-grid stages with coaxial line tuning elements. All the valves are air cooled and alternating current is used for heating the filaments. Duplicate transmitter drive units, fed simultaneously with the appropriate programme, are provided for each of the three services and either drive may be selected automatically with the other acting as spare.

Specially designed monitoring equipment has been installed to give a continuous indication of the centre frequency of any of the three transmitters. It also includes high-precision low-frequency oscillators for accurately measuring frequency deviation, noise and distortion.

The transmitter valves and other components are cooled by air supplied by a blower situated in a duct below the units. The warm air is exhausted through trunking running along the tops of the cabinets containing the equipment and can then be used for heating the building in cold weather.

OUTPUT ARRANGEMENTS

The outputs of one of the transmitters provided for each service are combined and connected to one half of a slot aerial, while those of the other three are connected to the other half through a separate feeder. Thus all three programmes are radiated by both halves of the aerial, thereby ensuring continuity of service in the event of failure of any part of the feeder or aerial system. This arrangement also enables the service to be maintained at reduced power should any transmitter cease to operate for any reason.

The outputs of the two transmitters serving any programme are correctly phased by automatic equipment. As the very-high-frequency apparatus has been designed to run unattended, the transmitters are switched on and off by time switches and are automatically monitored. The associated fault-indicator panel and alarm system have been designed to call attention to any faults which may develop during transmission and also to give warning if the equipment is not in a suitable condition for automatic operation.

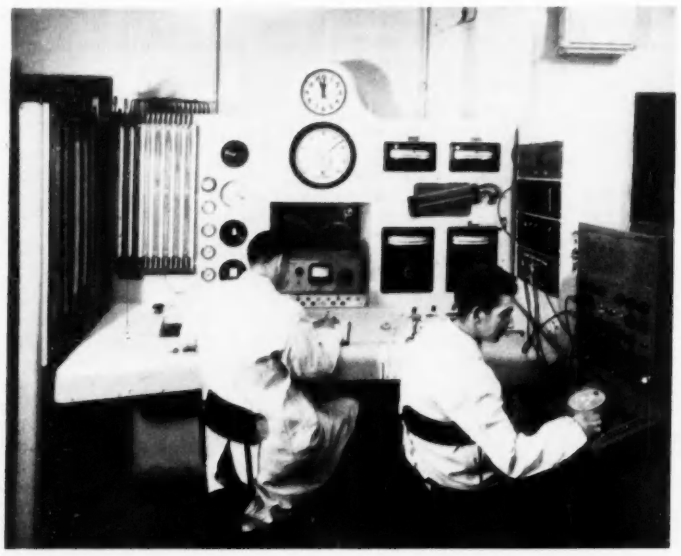
MAST AND AERIAL DESIGN

The very-high-frequency aerial system is carried on the 750 ft. mast which was built for the television service. It is situated at 1,750 ft. above sea level and weighs 140 tons, while the maximum downward thrust on the base pedestal under the most severe conditions is 350 tons. The base is located by a steel ball 2 in. in diameter, which is borne in a socket, thus forming a pivot to allow angular movement in high winds. The cross section is triangular up to the 610 ft. level, each face being 9 ft. wide. The cylindrical very-high-frequency aerial is fixed between the 610 ft. and 710 ft. levels. It consists of a hollow galvanised steel cylinder 6 ft. 6 in. in diameter and 100 ft. long, in which there are 32 slots, these slots being arranged in eight tiers of four to give a net power gain factor of 6 to 1. Thus the 20 kW output from each pair of transmitters is transformed into 120 kW of radiated power.

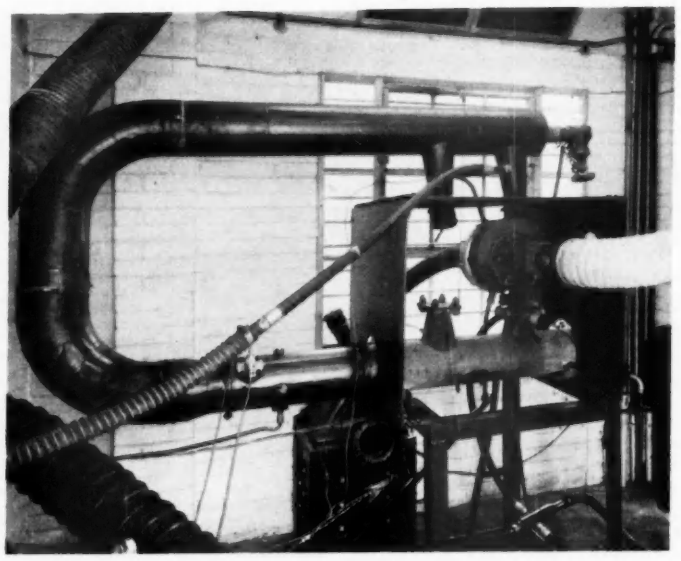
A short-sequence topmast carries the television aerial, and the mast as a whole is supported by four sets of stays. The stay ropes are of fully locked-coil construction in steel and have a breaking stress of 120 tons per sq. in. There is a safety factor of four under the most severe conditions, simultaneously including an overall coating of ice ½ in. thick, with a wind pressure of 65 lb. per sq. ft. at the mast-head. This corresponds to a wind velocity of 125 m.p.h. Under these conditions the lateral displacement of the mast-head would be about 7 ft. 6 in.

The aerial feeding arrangements and distribution feeders were designed, installed and matched by the Planning and Installation Department of the British Broadcasting Corporation. They include specially designed filters between the transmitter outputs and the combining units to reduce the possibility of spurious radiation which might be caused by intermodulation between the Home, Light and Third programme transmitter outputs.

Power for operating both the television and very-high-frequency equipment is obtained from the Yorkshire Electricity Board at 11 kV through duplicate feeders, one of which is spare and is automatically switched in in case of the breakdown of the other. It is stepped down to 415 volts in three 500 kVA transformers, of which two normally carry the load, and is distributed to the very-high-frequency equipment through two 300 ampere switch-fuses, each of which controls the supply to one set of three transmitters and their auxiliary equipment through a three-phase automatic voltage regulator. This arrangement ensures that in the event of a fault occurring in either of the power distribution chains, only half the station would be affected. An emergency lighting system is supplied from a 240-volt battery.



The observer's panel in C.A.V.'s main engine test laboratory, now fitted with additional instrumentation for testing turbo-charged engines on the dynamometer.



An experimental turbo-charger undergoing an endurance test, operating as a self-sustaining gas turbine. The blower delivery air is fed back through a combustion chamber, where Diesel fuel is burned.

EXHAUST TURBO-CHARGERS FOR HIGH-SPEED DIESELS

C.A.V. DEVELOPMENTS

The main trend of Diesel development is towards increased specific output, in particular by adoption of the turbo-supercharger which offers increased power with reduced fuel consumption.

In the marine and industrial fields, supercharging by means of exhaust-gas-driven turbo-chargers has become widely adopted as a means of increasing the output from an engine of given size and weight. Recently C.A.V. Limited, Acton, London, W.3, have been investigating their possibilities applied to road transport engines, where the low specific weight and improved specific fuel consumption offered are possibly of even greater importance. Problems of materials, blade design, bearing life and lubrication have all been tackled, and a promising design is now undergoing tests.

For this development it has been necessary to evolve specialised apparatus and techniques of measurement. For work on engines on a dynamometer bed, modifications to the existing set-up included the addition of a high-speed counter for blower speeds, manometers with permanent connections from the bed to the panel, and link cables for distant-reading electronic indicators. The illustration above, left, shows the additional instrument panel on the right.

For tests on turbo-blowers as individual units, a special test house was built. In this is housed a positive-displacement compressor, capable of delivering over 1,000 cub. ft. per minute of air, driven by a Leyland engine. The compressed air is delivered to a receiver, and then flows through a metering valve into an aircraft-type combustion chamber, where Diesel fuel is injected and ignited. The hot gases flow through the turbine end of the supercharger unit, driving the blower and exhausting to atmosphere. By this means the turbine and blower units may each be tested independently.

For endurance tests, after starting on air from the receiver, the turbo-charger delivery air is fed back by way of the combustion chamber to its turbine, the system being thus self-sustaining. The set-up is shown in the illustration, above right. A separate cubicle enables endurance testing to be carried on independently, while the test house proper can be used for performance testing. An automatic control and shut-down system enables the test cell to run continuously unattended. Remote control panels enable the observers to work away from noise and heat.

Ancillary equipment includes an electronic balancing machine for turbo-blower rotors, and a bearing-friction test machine. Speeds of 50,000 r.p.m. and over have been used in this work, and the bearing problem is therefore of first importance.

Since 1938, the production of Diesel engines has increased tenfold (based on the number of engine cylinders), and the range of fuel-injection equipment has grown accordingly. To cope with the increasing development demands, C.A.V. Limited are now in process of expanding their research and test facilities. Engine test beds and laboratories housing rigs and endurance test machines, injection pumps and other equipment will be brought under one roof in a new four-storey building now under construction. The building, designed for flexibility of all essential services, will have a floor space of 92,000 sq. ft.

★ ★ ★

PIPE COUPLING

At the recent Smithfield show, Sigmund Pumps Limited, Team Valley, Gateshead, 11, Co. Durham, were showing a new range of AutoJet sprinklers and quick couplings for irrigation pipes for crops. The sprinklers are designed to operate at pressures from 25 lb. per sq. in. with outputs of from 4 to 40 gallons per minute. The quick coupling is shown in the accompanying illustration. It is designed for pipes of about 3 in. in diameter. To make the connection, one half of the coupling is pushed on to one length of pipe and the latch portion on to another. Pushing the ends of the two pipes together then allows the catch to fall into the latch, making a pressure-tight joint with a large degree of flexibility. To disconnect, the two pipes are simply pushed together again, and one is rotated to disengage the latch. A rubber seat within the coupling forms the seal. The hexagon bolt that can be seen in the illustration can be withdrawn and replaced by a sprinkler head. By means of this coupling, irrigation pipes can be laid out over a field and removed very quickly and simply, without requiring skill or tools.

★ ★ ★

PLASTIC LAGGING

Lagging material, " Dohmlag," which is supplied in powder form is being made in this country by Dohm Ltd., 167 Victoria-street, London, S.W.1. Mixed to a paste by adding water, it can be used for lagging tanks or pipes. Small patches are first dabbed on to provide an undercoat and key, and when dry, the final coating 1 in. thick can be applied by hand and smoothed with a trowel or knife.

As the illustrations show, this quick coupling for pipes has a considerable degree of flexibility.

Book Reviews

DESIGNING EFFICIENT SHIPS

The Theory and Technique of Ship Design. By GEORGE C. MANNING. *The Technology Press of the Massachusetts Institute of Technology*, and *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.* (10 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (80*s.*)

The first step in the design process is taken by the shipowner. His estimate of the amount of cargo to be carried on a particular route and the freight rates over the period of from 3 to 30 years ahead is of fundamental importance. Professor Manning deals with design using the owner's requirements as the starting point, then discusses merchant ship design in terms of commercial efficiency, and warship design in terms of combat efficiency.

The features required for commercial efficiency include: low first cost, small fuel consumption and low tonnage dues for a given earning capacity, and good cargo stowage arrangements. As in any other design, the skill lies in balancing conflicting requirements; the choice of dimensions and structural arrangement desirable to reduce the cost of the hull, balanced against the best dimensions and hull shape for low fuel consumption; and both these factors considered in relation to cargo stowage, bunkers and ballast. But the particular requirement of ship design is that it must float, at all conditions of loading, with a reasonable fore and aft trim, and neither too much nor too little transverse stability. It is clear that the designer must have means of estimating the probable weights and centres of gravity of all parts of the ship and cargo quite accurately during the preliminary stages of design. It is this particular requirement which makes it possible to deal with warship and merchant ship design in the same book.

The type of merchant ship is largely settled by the nature and density of the cargo. The designer estimates total displacement to carry the specified deadweight; ship length and fullness to suit the designed speed; and breadth and draught to satisfy any port limitations in depth of water, freeboard requirements and initial stability. As soon as the designer has tentativly established the main dimensions, fullness, and suitable longitudinal position of centre of buoyancy, he will use data from a ship of similar type to examine possible arrangements. The author obtains his data on weights by means of a weight equation. He discusses the reasons for variation in each group of weights and obtains a series of differential rates. This is a general discussion applying to warships and merchant ships, but in each case the method depends on having accurate data for a ship of similar type.

It is not easy to ensure accurate analysis of weight data for an existing ship. For instance, the usual 8 per cent. of scrap margin between invoiced steel weight and steel actually built into the ship, allows considerable errors to creep in. There is no doubt that accurate and carefully analysed data give the designer much more freedom in design, and this is rightly emphasised by the author. Professor Manning also stresses the need for the designer to be "open-minded, entirely willing to consider new ideas and departures from current practice." This is the critical point of the "basic ship" design method. If a shipowner and shipbuilder use an existing ship as a prototype, correcting weaknesses found in service and taking advantage of any advances in technique and material, then design tends to progress. The danger lies in merely altering an existing ship sufficiently to satisfy a different specification without any designing in the true sense of the word. It is in most cases a lot easier to make the least possible changes from an existing ship, and ship design tends to contain vestigial remains. It is likely that the tendency to fit bulbous bows on many American ships, but rarely on British-built ships, stems from a difference in "basis ship."

The book is addressed to all those who have to do with the design, construction and operation of ships, as well as being a text in basic design. The author deals separately with the preliminary, contract and final design stages. The full treatment is necessary to the student of a "text in basic design." The demands of warship and merchant ship make the descriptive work rather long and rather disjointed. The discussion of ship lines and on powering is at a very elementary level and so brief as to tend to be misleading. Ship designers would like more detailed information, and an illustrated description of ship types designed for particular trades would be of interest to all readers. Although the book contains features of interest to all, it is aimed at too wide a range of readers to satisfy any one section fully.

THE ENGINEERING APPROACH

Industrial Engineering Handbook. Edited by H. B. MAYNARD. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (14.50 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (109*s.*)

This is the latest of the many engineering and management handbooks published by this company and, like its predecessors, it is a massive affair. Although the title "Industrial Engineering" is hardly known in this country, the opening chapter on its development is by one of the handful of British contributors, Lt.-Col. Lyndall Urwick. He quotes as his definition "the engineering approach applied to all factors, including the human factor, involved in the production and distribution of products or services."

As is usual in works of this nature, the chapters vary greatly in length and quality; some being mere magazine articles of an almost propagandist nature, and some miniature text-books on their subject. Among the latter, the sections on methods and on works measurement are very complete and appear to be up-to-date; they include an excellent chapter on motion study by Miss Anne Shaw. There are good chapters also on production planning and control and its associated techniques, and also on quality control; but it would be an advantage if there had been included a chapter on the basic theory underlying this and other statistical methods now coming into use in industry. There is at the end of the volume one short chapter on operations research, including linear programming, much of which would have been better incorporated in the chapter on production planning and control, in which there is no reference to mathematical methods.

A section which deals with predetermined-elemental-time standards contains useful chapters on methods-time measurement and on the work-factor system. There are also good short chapters on estimating (including some useful tables), plant layout, production-line techniques, and on planning and measuring maintenance and construction work.

It was perhaps to be expected that the sections and chapters on human problems would be the least illuminating, and there are only a few which deal with the subject at all. These include a number of chapters on the part played by managers and foremen in industrial engineering; a section on wage payment, which includes a chapter on industrial relations and others on various wage and incentive systems; and a chapter on personnel testing.

A chapter on the preparation of effective reports is contributed by a consultant in readability. This attempts to provide scientific criteria which may be used to judge the readability of written matter; it would be interesting to apply these criteria to some of the other chapters of the volume. On a related subject is an interesting chapter on graphical-presentation methods, which draws attention to the way people normally read the text accompanying illustrations, and comments on mistakes frequently made in laying out charts.

Although the specialist undoubtedly requires much more training and information than he can expect to get from any of the individual chapters of this handbook, nevertheless it can deservedly take its place on the works or production manager's shelf for consultation, or for dipping into in his spare moments.

★ ★ ★

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Photo-Electric Temperature Control. ELCONTROL LTD., 10 Wyndham-place, London, W.1. Photo-electric controllers for a temperature range from 750 deg. to 1,200 deg. C. One of these provides for the switching off of the heating current in resistance welding and other operations when the temperature has risen to the desired limit. The other permits on-off switching at predetermined temperatures, thus enabling a given temperature to be maintained. Technical details. Illustrated leaflet.

Spot Galvanometer. EVANS ELECTROSELENIUM, LTD., Harlow, Essex. Sensitive taut suspension galvanometer of robust and dust-proof construction, thus eliminating coil "stiction" or non-linearity owing to the entry of dust into the air gap. Two types available: current or voltage measuring unit with range switch to give three sensitivities or current measuring unit with stabilised power supply to facilitate the use of external photo-electric instruments. Illustrated leaflet.

Mobile Compressor. HYMATIC ENGINEERING CO. LTD., Redditch, Worcestershire. Hymatic-Hydrovane Type 7P100 rotary compressor, trolley-mounted, for spray-painting, tyre inflation, pneumatic tools, etc. Maximum delivery pressure 100 lb. per sq. in., capacity 7 cub. ft. per min. Illustrated descriptive leaflet.

Shot Cleaning Plant. KEITH BLACKMAN LTD., Mill Mead-road, London, N.17. "Tornado" shot cleaning plant for heat exchangers, boilers, superheaters, etc. Can be used without shutting down plant. Made under licence from AB A. Ekströms Maskinaffär, Stockholm. Leaflet No. 35.

Controller for Eight Oil Burners. ELCONTROL LTD., 10 Wyndham-place, London, W.1. Electronic fully automatic controller for light oil burners, particularly those of the domestic type. Principles of operation. Technical details. Illustrated leaflet.

Portable Generating Sets. ARTHUR LYON & CO. (ENGINEERS) LTD., 6 Carlos-place, Grosvenor-square, London, W.1. Alco 500 and 750 portable petrol-driven generating sets, output 500 watts and 750 watts respectively, available for direct or alternating current. Specification leaflet.

Guided Missiles. ALCO PRODUCTS, INC., Schenectady 5, New York, U.S.A. Alco, locomotive and heavy engineering company with defence manufacturing experience, state their case for guided-missile manufacture. Illustrated brochure.

Sub-Miniature Relay. D. ROBINSON & CO., 58 Oaks-avenue, Worcester Park, Surrey. Hopwood-Par sub-miniature version of 3,000 type relay measuring 1⅛ in. long by ½ in. wide. Weight 1¼ oz. Can be fitted with up to four sets of changeover contacts. Leaflet.

Ceramic Player Pick-up. TECHNICAL CERAMICS LTD., Wood Burcote-way, Towcester, Northamptonshire. Barium titanate reproducer element with sapphire stylus. Turnover unit for both standard and long-playing records. Leaflet.

Marketing

ON WORLD TOURS

It has become the fashion for service executives of large companies to hold Press conferences on their return from overseas visits giving their impressions of what they have seen. Usually it is a cheerful picture they paint, of tremendous opportunities for British products in expanding economies, but in very general terms. The journalist is often left with the feeling that he has little to tell his readers, except that it would do them good from time to time to escape to sunnier lands. But perhaps it would be too much to expect factual information on opportunities for competitors, or detailed analyses of demand for chemical plant in Panama or heat pumps in Mexico. We must be content with the stimulating effect of the story of the man who has just returned and hope that it will lead to many others setting out on similar missions.

Mr. C. R. D. Tuckey, general sales manager of British Timken Limited, returned recently from his third world tour which took him to British East Africa, Rhodesia, South Africa, Australia, New Zealand and Canada, where his company sell most of their tapered roller bearing exports. He was introduced by Mr. John Pascoe, chairman and managing director of the company. Mr. Tuckey's main purpose was to advise and assist agents, distributors and overseas representatives of British Timken, and he saw also many large users of their bearings. The company are highly successful exporters of bearings, and look to export markets to absorb a large proportion of the additional capacity created by the £2½ million expansion programme undertaken during the past four years. Total exports, which include all the bearings used in Australian-made Holden cars, already exceed £2 million a year.

Mr. Tuckey found that, in the three years which have elapsed since his last tour, the rate of industrialisation of the markets he visited has greatly increased, particularly in Australia and Canada. United States manufacturers continue to dominate the Canadian market, but there has been a major increase in competition from Germany. This increase in competition, which he found to be general, makes it more essential than ever that senior British executives should strike out to look for new business and to consolidate what they already hold.

★ ★ ★

Selling Goodwill

A nice little lecture was delivered by Mr. J. H. Brebner, public relations adviser, British Transport Commission, to the Institute of Transport at their annual general meeting in December. The ground covered was familiar enough: tell people what you intend to do before you do it and explain it to them; keep them fully informed of what goes on because if you do they are much more likely to see your point of view; create understanding and you will get co-operation. Paradoxically, perhaps, the problem of communications (with staff and with customers) is probably greater in transport than in any other industry, because people work alone or in small groups, are widely dispersed, work in shifts or—if users—have nothing concrete to take home except their impression of how they were treated. Mr. Brebner's reminder that there exists widespread prejudice against nationalised undertakings and that they must therefore "take particular care in all their dealings with the public to avoid . . . those errors of arrogance, bureaucracy and lack of business sense which their critics so freely—and, I suspect, so gladly—accuse them," was more than justified. It places a special burden on the public relations departments of those industries which provide a service to the public.

It is a pity that Mr. Brebner did not say more on the techniques that have been developed in recent years to improve the effectiveness of public relations. They are as yet little known in industry; were they better appreciated and more widely used much of the friction between labour and management, arising largely from misunderstandings, could be avoided.

★ ★ ★

Door-to-Door Selling

The increase in competition, and the greater sales resistance created by credit and hire purchase restrictions, call for new and more direct methods of sale. A host of engineering products, such as radio sets, refrigerators, vacuum cleaners, sewing machines, etc., have in the past been sold by men pounding the pavement and calling on the householder. The clamorous demand of the post-war years, and the difficulty of recruiting salesmen, made such direct selling unnecessary. In the United States they have returned earlier and have been developed further than in pre-war days. In this country more and more companies are now turning their thoughts to house-to-house selling as a means of reaching the customer more efficiently and therefore more economically than the traditional wholesale and retail channels. One of the main advantages is that the salesman has, for a brief period, the full attention of the housewife—provided that she is not thinking about the cakes that she has left in the oven, or the heavy wash that the salesman has interrupted.

In the United States one of the most successful protagonists of this method of sale is the Fuller Brush Company, whose products include the Electrolux vacuum cleaner as well as brushes and cosmetics. They are able to sell more vacuum cleaners than any of their competitors at 89·75 dols. with no discount, compared to the 50 dols. at which some of their competitors' models are selling. The same method is being used to sell hot water and central heating boilers, oil burners and other products which require installation and servicing (previously thought to exclude them from the range of items saleable to the housewife).

There is in this country a general reluctance to use such direct sales methods. Yet the alternative is to pay discounts, which amount up to 40 per cent. to distributors and dealers handling a very wide range of different products who have themselves only incidental contact with the customer. The success of American firms with door to door selling warrants at least a trial in this country.

★ ★ ★

Readership Survey in India

The Times of India Group of publications recently published their second readership survey—the first was in 1939—based on the analysis of over 68,000 questionnaires, constituting some 17 per cent. of the group's total readership' Prizes were offered for answers to one question, in order to obtain a better response. The authors point out that this may have led to more distortion, since wealthier readers would not be so attracted, but the fact that rather more than one reader in four filled in the questionnaire printed in the *Times of India* suggests that the response was exceptionally good.

The results are full of interest for the British manufacturer of goods that India is currently importing. Asked to put in order of importance the items which would be bought if a large sum of money suddenly became available, a house came first, followed by good clothes, a motor car, a radiogram, and a trip around the world. Refrigeration came seventh, air conditioning eighth, washing machine twelfth. On the whole the readers are the educated few (only 15½ per cent. had not reached matriculation standard and 39 per cent. had degrees), 46 per cent. live in the Bombay area, the largest category of readers are students (15½ per cent.), followed by civil servants and clerks (13 per cent. each) and business men (12 per cent.). Information on incomes (only one-fifth earned more than 500 rupees a month), on the ownership of durable goods (14 per cent. had a motor car but only 3 per cent. had a refrigerator), and on habits and hobbies is both interesting and useful.

A study of the survey report is well worth the while of all those who export consumer goods to India and of everyone who has a major stake in Indian trade.

★ ★ ★

Telex to Canada

The rapid improvement in communications between this country and North America which has followed the installation of the transatlantic cable is such that one can only hope that more cables will be laid during the next few years. Apart from being able to talk to New York as if it were from Mayfair to Whitehall, there is now a telex service via the cable. The charges are moderate—£3 for a call of three minutes or less and £1 for each additional minute or part of a minute.

★ ★ ★

ELECTRICAL CONTROLS ON THE "JOHN BISCOE"

Ease of manoeuvre, an important characteristic of Diesel-electric ship propulsion, is a matter of safety as much as convenience when navigating in partly icebound waters. The new Royal Research Ship "John Biscoe" of the Falkland Islands Dependencies Survey, which was due to rendezvous with the Royal Yacht and H.M.S. Protector on January 1 at Deception Island to give the Duke of Edinburgh an opportunity to visit some of these Antarctic regions, has been designed for maximum flexibility in this respect.

Its electrical equipment is interesting for the simple manner in which sensitive and rapid control of the 1,350 h.p. propulsion motor is achieved, speed and direction of rotation being variable by adjustment of a potentiometer in a field circuit of the control exciter providing excitation for the main generators. By acting through a control exciter in this way, instead of directly on the main generator field, only relatively low currents are handled and the potentiometer serves both as speed regulator and reverser. A similar principle, although on a more elaborate scale, is widely used to-day in heavy industrial drives, particularly in steelworks, with automatic speed control against a pre-set reference voltage on the closed-loop system. In the John Biscoe, speed control up to half speed is entirely through the generator excitation, while from half to normal top speed the Diesel engines are accelerated and simultaneous generator-field adjustments are made. In the lower half of the speed range, auxiliary notches are available between the main controller notches so that 16 propulsion motor speeds in either direction may be selected for manoeuvre. An emergency top speed is obtained by weakening the propulsion motor field.

The John Biscoe, which was described in the December 7 issue of ENGINEERING, was built by Fleming and Ferguson, Limited, at Paisley, and her propulsion equipment has been supplied by the National Gas and Oil Engine Company, Limited and the General Electric Company, Limited. She sailed on November 26 on the first of her 27,000-mile round trips carrying stores from Southampton to the ten Antarctic bases established by the Falkland Islands Dependencies Survey for scientific and meteorological work.

RAILWAY ELECTRIFICATION CONTINUED

The introduction of electric traction between Shenfield and Southend-on-Sea in the Eastern Region of British Railways on December 31, 1956, a distance of 21¼ miles, marked the completion of a scheme, the first part of which (between Liverpool Street and Shenfield) was placed in operation in 1949, and an extension from Shenfield to Chelmsford followed in June, 1956. These electrified lines are at present being operated by direct current at 1,500 volts, but provision has been made to convert them to the high-voltage single-phase alternating-current system recently adopted by British Railways.

As a result of this conversion a total of 119 trains will be run daily between the two terminals from Monday to Friday, compared with 64 steam trains at present, while on Saturdays and Sundays the facilities, although less, will be better with electric than with steam traction. During the morning and evening week-day peaks the electric trains will provide seats for 18,150 passengers, compared with 11,760 by steam. There will also be a reduction in the time taken on the journey. In addition, the Diesel services on the Wickford-Southminster branch have been improved to give better connections. Another feature of the new service is the specially designed all-steel electric rolling stock, consisting of a combination of compartment and open saloon coaches to meet the needs of both business and holiday travellers with luggage.

POWER SUPPLY

A supply of power for operating the newly electrified branch is obtained from the Eastern Electricity Board at 33 kV three phase. This is brought in to substations at Ramsden Bellhouse, Rayleigh and Prittlewell, which are situated about 7 miles, 14 miles and 20 miles from Shenfield. The equipment at Ramsden Bellhouse consists of a 33 kV single busbar metal-clad switchboard, the main circuit-breaker on which has a rupturing capacity of 500 MVA and controls the supply to a 2,000 kW, 1,500 volt pumpless steel rectifier. This rectifier has been designed for twelve-phase operation and comprises two units in separate cubicles.

The alternating-current switchboard also controls the supply to duplicate 30 MVA, 33,000/650/615/240 volt plug-in auxiliary transformers from which the three-phase auxiliary and the single-phase signal circuits are fed. The supplies for the latter are taken through a Brentford regulating transformer, so that the voltage is maintained within ± 1 per cent. at 650 volts. The direct-current output from the rectifier is controlled by high-speed circuit-breakers of the truck-mounted type, a design which has been adopted to ensure rapid and easy maintenance.

The equipment at Rayleigh substation is identical with that at Ramsden Bellhouse, except that the alternating current switchgear is rated at 750 MVA and there is only one plug-in transformer. At Prittlewell the rating is the same as at Rayleigh, although the rectifying equipment is in duplicate. In addition to the substations, track sectioning cabins have been built at Billericay, Fanton and Stellarys. These are located about half-way between the substations and are each equipped with four high-speed circuit-breakers. Both the substations and the track section cabins are operated from the existing control station at Chadwell Heath.

The overhead-line equipment, the appearance of which will be clear from Fig. 1, is similar to that in use on the Liverpool Street-Shenfield line, except that the total copper equivalent has been reduced from 0·75 sq. in. to 0·6 sq. in. per track. The main and auxiliary catenaries are of hard-drawn copper and the contact wire is of cadmium-copper alloy. The line equipment is generally supported on steel structures, which are spaced up to a maximum of 240 ft. apart. Between Rockford and Prittlewell, however, seven prestressed concrete structures have been erected as an experiment.

ALL-STEEL ROLLING STOCK

The new electric rolling stock which is being used on the Liverpool Street—Southend-on-Sea line consists of 32 all-steel four-coach multiple-unit sets, each of which is made up of a driving trailer, a motor coach, a trailer and a second driving trailer. There is seating accommodation for 19 first class and 344 second class passengers. Of the latter 140 are accommodated in open-type vehicles with a central passageway and the remainder in compartment type coaches. The exterior appearance is shown in Fig. 1.

Current is collected by a pantograph on the motor coach and passes through two overload relays each of which controls a pair of the four main traction motors. These motors, which are of the axle-hung nose-suspended type, are connected permanently in series, one pair being mounted on each bogie of the motor coach, and are cooled by air taken in through protected inlets on the top of the frame. A view of one of the bogies appears in Fig. 2. The continuous rating of each unit is 632 h.p. with a full and 696 h.p. with a weak field, the corresponding one-hour ratings being 800 h.p. and 880 h.p.

CONTROL AND PROTECTION

The control equipment is of the electro-pneumatic contactor type, which enables the two pairs of motors to be connected either in series or in parallel bridge with transition. Either pair of motors can be isolated by a hand-operated switch, which also makes the necessary modifications in the control circuit. The contactors with the associated relays, reversers and motor cut-out switches are accommodated in three cases which are carried under the coach. They are operated from master controllers which are provided with a shunting notch and three running notches in the two driving trailers. On the shunting notch all the resistance is in circuit thus permitting slow running. Movement of the controller to the series, parallel or weak-field positions initiates automatic acceleration over nine resistance notches to full series and over a further four to full parallel. There is one weak-field running notch, which is reached through an intermediate step. In this position portions of the motor fields are diverted through resistances, while on the final step they are weakened by tapping. A separate current relay is used to reduce the demand when taking the weak-field steps and also to keep the current peaks within reasonable limits.

Two rates of acceleration can be selected by using alternative "forward" positions of the reverser handle—1·1 m.p.h. and 0·85 m.p.h. per second—the latter being intended for employment in greasy rail conditions.

As regards protection, the operation of an overload relay causes a resistance to be brought into circuit before the current is broken by a line switch. When an overload relay trips, auxiliary contacts energise an indicating relay and cause a lamp to light in the van compartment of the motor coach. In the event of a failure of the supply a no-current relay opens all the line switches and contactors. The equipment re-notches automatically to the condition dictated by the master controller when the supply is restored.

The butt contactor interlocks in the control contactors are under Perspex covers and the electro-pneumatic valves are mounted at the

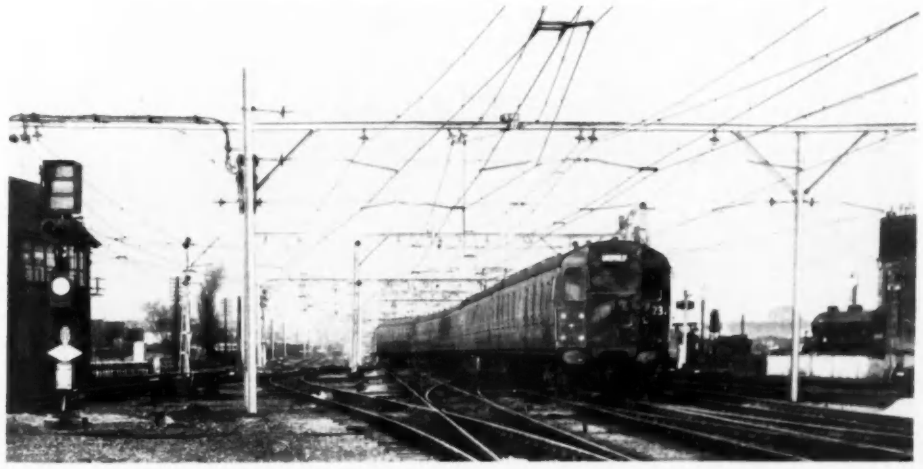


Fig. 1 (above) View of eight-car multiple-unit electric train on the newly converted Shenfield-Southend-on-Sea line. The photograph also shows the construction of the overhead equipment.

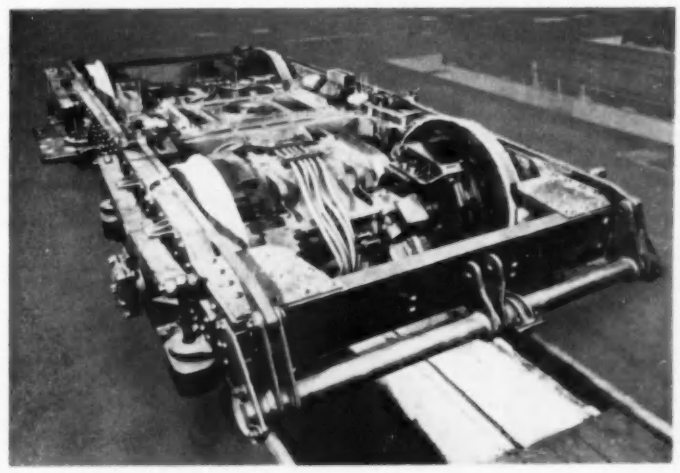


Fig. 2 (right) One of the bogies carrying two axle-hung non-suspended self-ventilated motors.

Fig. 3 Low-tension cubicle showing foot pump for raising pantograph in an emergency.

front so that both are accessible. The trains are equipped with a new design of control receptacles and jumpers with butt contacts, which are designed to simplify the coupling up of trains and to ensure good contact at all points with positive locking of the jumper in position.

SIGNALLING AND CIVIL ENGINEERING

Traffic on the Shenfield branch has been controlled by direct-current colour light signalling since 1938. The present electrification has, however, necessitated the conversion of the supply system to alternating current, although the existing signals have been retained. This has involved alteration of 170 track circuits, 112 of which have been provided with impedance bonds. A new relay room has also been built at Wickford and 112 lineside apparatus cases have been installed. Almost 1,000 relays of the plug-in type, to facilitate maintenance, have been used.

A supply of power for signalling is, as mentioned above, obtained at 650 volts, 50 cycles, through equipment installed in the Ramsden Bellhouse and Prittlewell substations. A 20 kVA stand-by Diesel generator is also available at Ramsden Bellhouse. This cuts in automatically and takes up full load in about 7 seconds, should the normal supply fail. The signal lamps are operated by direct-current through a step-down transformer and selenium rectifier from a 110 volt alternating-current supply.

The conversion of the Southend branch from steam to electric traction has involved comparatively little civil engineering work. Nine road overbridges, however, have had to be raised to obtain the necessary clearance for the overline equipment and two of these were also widened. In addition, five steel footbridges were raised, while other work consisted of constructing substation buildings and track sectioning cabins, the lengthening of platforms, the strengthening of embankments and cuttings, and the relaying and deep ballasting of the permanent way. The railway officers responsible for the above work were Mr. S. B. Warder, chief electrical engineer, Mr. J. A. Broughall, electrical engineer (development), both of the British Transport Commission; and Mr. K. J. Cook, chief mechanical and electrical engineer, Mr. R. A. Green, signal engineer and Mr. A. K. Terris, civil engineer, of the Eastern Region, British Railways.

The contractors for the overhead line equipment were British Insulated Callender's Construction Co., Ltd., Leicester-square, London, W.C.2; for the substation and track sectioning cabin equipment the British Thomson-Houston Co., Ltd., Rugby; and for the power, supervisory and pilot cables British Insulated Callender's Cables Ltd., Norfolk-street, London, W.C.2, and Johnson and Phillips, Ltd., Charlton, London, S.E.7. The rolling stock was constructed at the Eastleigh carriage and wagon works of British Railways, the electrical equipment being supplied by the General Electric Co., Ltd., Kingsway, London, W.C.2. The contractor for the signalling work was Siemens and General Electric Railway Signalling Co., Ltd., Wembley.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Generation of Electricity by Nuclear Energy," by J. R. M. Southwood and J. Thompson. West London Branch. 134 King-street, Hammersmith, W.6. Tues., Jan. 8, 7.30 p.m.

BIRMINGHAM
"Properties of Silicones and Their Application in Electrical and Engineering Industries," by J. J. Newlands and G. L. Towers. Birmingham Branch. Birmingham Exchange, Stephenson-place, Birmingham. Wed., Jan. 9, 7.30 p.m.

BRADFORD
Discussion on "Earthing Systems." Bradford Branch. Midland Hotel, Bradford. Wed., Jan. 9, 8 p.m.

HALIFAX
"Further Thoughts on Television," by H. B. Reeder. Halifax Branch. Crown Hotel, Horton-street, Halifax. Wed., Jan. 9, 7.30 p.m.

British Institution of Radio Engineers

LONDON
Films on "Radio and Electronic Engineering." London Section. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Jan. 9, 6.30 p.m.

EDINBURGH
"Potted Components and Assemblies," by H. G. Manfield. Scottish Section. Department of Natural Philosophy, The University, Edinburgh. Fri., Jan. 11, 7 p.m.

WOLVERHAMPTON
"Design and Application of Magnetic Amplifiers," by R. G. Russell-Bates. West Midlands Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Wed. Jan. 9, 7.15 p.m.

Building Centre

LONDON
Film: "The Yorkshire Way with Water," exhibited by the Yorkshire Copper Works Ltd. Wed., Jan. 9, 12.45 p.m.

Chemical Engineering Group

LONDON
"Use of Multi-Wall Paper Bags in the Chemical Industry," by A. R. Hutchinson. Society of Chemical Industry, 14 Belgrave-square, S.W.1. Tues., Jan. 15, 5.30 p.m.

Illuminating Engineering Society

LONDON
"Lighting as an Effective Aid to Architecture," by H. R. Ruff, H. E. Bellchambers and R. V. Mills. E.L.M.A. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Tues., Jan. 8, 6 p.m.

EDINBURGH
"The Electrical Contractor's Approach to Artificial Lighting," by E. Cassidy. Edinburgh Centre. Y.M.C.A., 14 South St. Andrew-street, Edinburgh. Wed., Jan. 9, 6.15 p.m.

NEWCASTLE-UPON-TYNE
"Lighting of Small Factories," by J. S. McCulloch. Newcastle-upon-Tyne Centre. Department of Electrical Engineering, King's College, College-road, Newcastle-upon-Tyne, 1. Wed., Jan. 9, 6.15 p.m.

Incorporated Plant Engineers

LONDON
"Acoustics and Vibration," by W. A. Hines and D. C. Smart. London Branch. Royal Society of Arts, John Adam-street, W.C.2. Tues., Jan. 8, 7 p.m.*

EDINBURGH
"Electronics in Industry," by R. B. Smith. Edinburgh Branch. 25 Charlotte-square, Edinburgh. Tues., Jan. 8, 7 p.m.

GLASGOW
"Current Lubricants and Their Significance to Plant Engineers," by S. F. Chisholm. Glasgow Branch. Scottish Building Centre, 425/427 Sauchiehall-street, Glasgow. Thurs., Jan. 10, 7.15 p.m.

LEICESTER
"Incentive Schemes for Maintenance Work," by D. J. Winfield. Leicester Branch. Bell Hotel, Leicester. Wed., Jan. 9, 7 p.m.

MANCHESTER
"Floor Loadings," by S. C. Swann. Manchester Branch. Engineers' Club, Manchester. Tues., Jan. 8, 7.15 p.m.

NOTTINGHAM
"Severn Barrage Scheme," by B. D. Richards. East Midlands Branch. County Hotel, Theatre-square, Nottingham. Wed., Jan 9, 7 p.m.

Institute of British Foundrymen

ACCRINGTON
"Hot Blast Cupolas," by J. Henderson. Burnley Section. Accrington College of Further Education, Sandy-lane, Accrington. Wed. Jan. 9, 7.30 p.m.

DUNDEE
"Malleable Castings for the Engineering Industry," by H. J. M. Conacher. Scottish Branch. University College, Dundee. Wed., Jan 9, 7.30 p.m.

SHEFFIELD
"Foundry Maintenance," by G. J. Jenkins. Sheffield Branch. Department of Engineering, College of Commerce and Technology, Pond-street, Sheffield. Mon., Jan. 7, 7 p.m.

Institute of Marine Engineers

LONDON
"The Application of Research to the Design of Marine Steam Turbines," by Dr. T. W. F. Brown. Tues., Jan. 8, 5.30 p.m.*

GLASGOW
"Cast Irons in Marine Engineering," by E. M. Currie. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., Jan. 9, 7.30 p.m.

LIVERPOOL
"Some Aspects of Alternating-Current Auxiliaries for Marine Use," by Commander D. W. Malim. Merseyside and North Western Section. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Mon., Jan. 7, 6.30 p.m.

Institute of Metals

OXFORD
"Gases in Metals," by Dr. C. E. Ransley. Oxford Local Section. Cadena Café, Cornmarket-street, Oxford. Tues., Jan. 8, 7 p.m.

Institution of British Agricultural Engineers

LONDON
"Economics of Machinery Investment on the Farm," by F. G. Sturrock and J. R. Warburton. Tues., Jan. 8, 5.30 p.m.*

BIRMINGHAM
"Requirements of Machinery Designed for Overseas Markets," by J. E. Mayne. West Midlands Centre. Chamber of Commerce, 95 New-street, Birmingham, 2. Mon., Jan. 7, 7.30 p.m.

Institution of Chemical Engineers

LONDON
"Solution of the Equations for Mass-Transfer in Plate-Type Distillation Columns," by H. H. Rosenbrock. Geological Society, Burlington House, Piccadilly, W.1. Tues., Jan. 8, 5.30 p.m.

Institution of Civil Engineers

LONDON
"Organisation and Control of Highways Maintenance," by W. J. Hiscock. Road Division. Tues., Jan. 8, 5.30 p.m.*
Vernon Harcourt Lecture on "Inalnd Waterways," by C. M. Marsh. Wed., Jan. 9, 5.30 p.m.*
"Application of Works Study to Railway Civil Engineering Maintenance," by P. D. T. Pescod and J. C. F. Cameron. Railway Division. Thurs., Jan. 10, 5.30 p.m.*

EDINBURGH
"Fertiliser Factory, Leith Docks," by J. P. A. Macdonald, L. Gordon and C. M. Wilson. Edinburgh and East of Scotland Association. North British Hotel, Edinburgh. Wed., Jan. 9, 6 p.m.

MANCHESTER
"Analysis of Prestressed-Concrete Structural Members and the Application of Recent Research," by Dr. P. B. Morice. North Western Association. Engineers' Club, Albert-square, Manchester. Thurs., Jan. 10, 6.30 p.m.

Institution of Electrical Engineers

LONDON
"A Theoretical and Experimental Investigation of Anisotropic-Dielectric-Loaded Linear Electron Accelerators," by R. B. R. Shersby-Harvie, L. B. Mullett and others. Joint Meeting of the Measurement and Radio Sections. Tues., Jan. 8, 5.30 p.m.*
"Some Aspects of Heat-Pump Operation in Great Britain, with Particular Reference to the Shinfield Installation," by Miriam V. Griffith. Thurs., Jan. 10, 5.30 p.m.*

BELFAST
"New Developments in High-Frequency Electric Motors," by C. Snowden. Northern Ireland Centre. Engineering Department, Queen's University, Belfast. Tues., Jan. 8, 6.30 p.m.

BIRMINGHAM
Discussion on "Recruitment to the Engineering Profession." South Midland Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Jan. 7, 6 p.m.*

BRIGHTON
"Crystal Palace Television Transmitting Station," by F. C. McLean, A. N. Thomas and R. A. Rowden. Southern Centre. Brighton Technical College, Brighton. Wed., Jan. 9, 6.30 p.m.

MANCHESTER
"Earth Loop Resistance Measurement," by Dr. G. F. Tagg.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Engineering Group, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institution of British Agricultural Engineers, 6 Buckingham-gate, London, S.W.1. (TATe Gallery 8589.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineers-in-Charge, 100 Earlsfield-road, London, S.W.18. (BATtersea 1394.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Institution of Water Engineers, Parliament Mansions, Abbey Orchard-street, London, S.W.1. (ABBey 6740.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool 2. (Central 3717.)
Manchester Association of Engineers, 18 Booth-street, Manchester 2. (Central 1717.)
Newcomen Society, Science Museum, Exhibition-road, London, S.W.7. (KENsington 1793.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. (BELgravia 3681.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)
South Wales Institute of Engineers, Park-place, Cardiff. (Cardiff 23296.)
West of Scotland Iron and Steel Institute, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)

North Western Centre. Engineers' Club, Albert-square, Manchester. Tues., Jan. 8, 6.15 p.m.
NOTTINGHAM
"Electrical Energy from the Wind," by E. W. Golding. East Midland Centre. College of Arts and Crafts, Waverley-street, Nottingham. Tues., Jan. 8, 6.30 p.m.

Institution of Engineering Designers

LONDON
"The Demands of Inspection on Engineering Design," by E. W. Greensmith. Tues., Jan. 15, 6.45 p.m. (Change of programme.)

Institution of Engineers-in-Charge

LONDON
"Automatic Level Control in Boilers," by C. G. Scolding. St. Bride Institute, Bride-lane, Fleet-street, E.C.4. Wed., Jan. 9, 6.30 p.m.*

Institution of Heating and Ventilating Engineers

LONDON
"Mechanical Services in the Central Area of London Airport," by R. E. Tully. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Jan. 9, 6 p.m.*

Institution of Mechanical Engineers

LONDON
"A Review of Hydro-Kinetic Fluid Drives and Their Possibilities for the British Motor Industry," by J. G. Giles. Automobile Division General Meeting, in conjunction with the Hydraulics Group. Tues., Jan. 8, 6 p.m.*
Discussion on "Diagnosis of Causes of Plain Bearing Failure." Lubrication Group. Thurs., Jan. 10, 6.45 p.m.*
"An Analogue for High-Intensity Steady-Flow Combustion Phenomena," by Dr. D. B. Spalding. Meeting in conjunction with the Internal Combustion Engine Group. Fri., Jan. 11, 6 p.m.*
LEICESTER
Annual General Meeting. "A Standard Gas Turbine to Burn a Variety of Fuels," by G. B. R. Feilden, J. D. Thorn and M. J. Kemper. East Midlands Branch. College of Technology and Commerce, Leicester. Wed., Jan. 9, 7.15 p.m.
NEWCASTLE-UPON-TYNE
Annual General Meeting. "An Approach to the Techniques of Graduate Training," by D. L. Marples, F. A. Radford and J. L. Reddaway. North Eastern Branch. Stephenson Building, Newcastle-upon-Tyne. Mon., Jan. 7, 6 p.m.

Institution of Production Engineers

LONDON
"Broaches and Broaching," by W. E. Soden. London Graduate Section. Tues., Jan. 8, 7.15 p.m.
DERBY
"Time and Motion Study in the Automobile Industry," by A. J. Hornsby. Derby Section. Derby and District College of Art, Green-lane, Derby. Fri., Jan. 11, 7 p.m.
LEICESTER
"Mechanical Handling." "Truck Methods," by R. A. Bishop; and "The Ohrnell System," by A. Brown. Leicester Section. Grand Hotel, Leicester. Thurs., Jan. 10, 7 p.m.
LIVERPOOL
"Cutting Tools: Application and Research," by M. O. Short. Liverpool Section. Bradford Hotel, Tithebarn-street, Liverpool. Wed., Jan. 9, 7.30 p.m.

Institution of the Rubber Industry

LONDON
"Phenolic Resins as Reinforcing Agents," by S. M. Ardley, at 5.30 p.m.; and "Electronic Force Mesurement in Rubber Testing," by A. E. Eagles and A. R. Payne, at 7 p.m. London Section. 26 Portland-place, W.1. Tues., Jan. 8.

Institution of Structural Engineers

LONDON
"Static Stresses in Electric Overhead Travelling Crane Girders," by Dr. E. Lightfoot and Dr. N. Jackson. Thurs, Jan. 10, 6 p.m.

Institution of Water Engineers

LONDON
"The Water Supply of Singapore," by W. S. Stredwick. South Eastern Section. Institution of Civil Engineers, Great George-street, S.W.1. Fri., Jan. 11, 2.30 p.m.

Junior Institution of Engineers

LONDON
"Metal Bonding," by R. A. Johnson. Fri., Jan. 11, 7 p.m.*

Liverpool Engineering Society

LIVERPOOL
"Mineral Insulated Metal-Sheathed Cables," by J. A. McCleery. Wed., Jan. 9, 6 p.m.

Manchester Association of Engineers

MANCHESTER
"Arbitrations and Awards," by G. D. Walford. Engineers' Club, Albert-square, Manchester. Fri., Jan. 11, 6.45 p.m.

Newcomen Society

LONDON
"Crampton Locomotive"—Part II, by P. C. Dewhurst. Iron and Steel Institute, 4 Grosvenor-gardens, S.W.1. Wed., Jan. 9, 5.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"Comprehensive Trials of Complete Marine Propulsion Turbine Installations," by Commander H. E. C. Hims. Mining Institute, Newcastle-upon-Tyne. Fri., Jan. 11, 6.15 p.m.*

Royal Aeronautical Society

LONDON
"Significance of Flow Separation in Three Dimensions," by E. C. Maskell. Section Lecture. Tues., Jan. 8, 7 p.m.

Sheffield Metallurgical Association

SHEFFIELD
Annual General Meeting of the Methods of Analysis Group, and Chairman's Address by W. Wright. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield, 3. Tues., Jan. 8, 7 p.m.

Society of Chemical Industry

LONDON
"Corrosion Problems in Nuclear Power Production," by A. B. McIntosh. Wed., Jan. 9, 6.30 p.m.

Society of Instrument Technology

LONDON
"Electronic Automation of Machine Tools," by F. T. Lett. 26 Portland-place, W.1. Thurs., Jan. 10, 7 p.m.*

South Wales Institute of Engineers

CARDIFF
"Drifting at Pentreclwydau Colliery," by E. J. H. Nicholas. Thurs., Jan. 10, 6 p.m.

West of Scotland Iron and Steel Institute

GLASGOW
"Metallic Recuperators," by W. Ernest and C. B. Tupholme. Fri., Jan. 11, 6.45 p.m.

FLAMEPROOF LAMP

A lamp suitable for photography in coal mines has been produced by the United States Bureau of Mines. It is colour-corrected and therefore photographs can be taken without filters. The lamp has a power of 1,000 watts, and special cooling is employed to maintain the exterior surfaces below the heat limit of 400 deg. F. as specified in the Bureau testing regulations. An internal fan circulates the air, and the exterior of the aluminium shell is fitted with fins to improve the cooling surface. The entire unit weighs 25 lb., and is shown in the accompanying illustration. This is believed to be the first colour-corrected lamp which can be used for taking motion or still photographs in any mine whether classed as "gassy" or "non-gassy." It can, of course, also be used in other places where explosion hazards exist, but so far it has only been tested for methane gas and coal dust.

★ ★ ★

This 1,000 watt lamp is explosion proof and can be used for taking colour photographs in hazardous areas, such as coal mines.

POWER ASSISTED STEERING

A new addition to the Fordson Major tractor as shown at the recent Smithfield show was the fitting of power-assisted steering. The system comprises a front-mounted control reservoir and pump assembly driven by a V-belt from the crankshaft pulley. The pump is capable of delivering two gallons of oil per minute, at 400 lb. per sq. in. operating pressure. This oil operates a double-acting ram which incorporates a shuttle valve assembly to direct the oil flow. The mounting arrangement is shown in Fig. 1, and the principle in Fig. 2.

Any slight movement of the steering wheel is transmitted through the steering drop arm and the drag link to the shuttle valve assembly. This valve is sensitive, and only a slight movement is required to allow oil from the pump to feed into one or other side of the power cylinder. As the oil from the pump enters the cylinder, the pressure builds up until it is sufficient to force the cylinder and the steering-spindle arm either to the front or to the rear according to the direction of turn. When pressure on the steering wheel stops, the shuttle valve spool is returned to the neutral position and power assistance ceases but the the wheels remain at same angle. Normal manual steering is immediately effective if the engine is stalled or switched off.

Apart from the advantage of giving sensitive steering on rough ground, any shocks taken by the front wheels of the tractor are damped before reaching the steering wheel. The initial pressure required to actuate the shuttle valve is just sufficient to maintain "feel" when steering. Another addition to the tractor as shown at the show, is the double clutch assembly, supplying a live power take-off shaft. The clutch is operated by a single pedal, which in the up position engages both the transmission clutch and the power take-off clutch; in the half depressed position, frees the transmission, but keeps the P.T.O. clutch engaged; and when fully depressed, disengages both transmission and P.T.O. The P.T.O. shaft also drives the hydraulic pump. A foam-rubber padded seat which can be moved backwards to give a standing position for the driver and can also be tilted forward to protect it from rain, is another addition to the recent models.

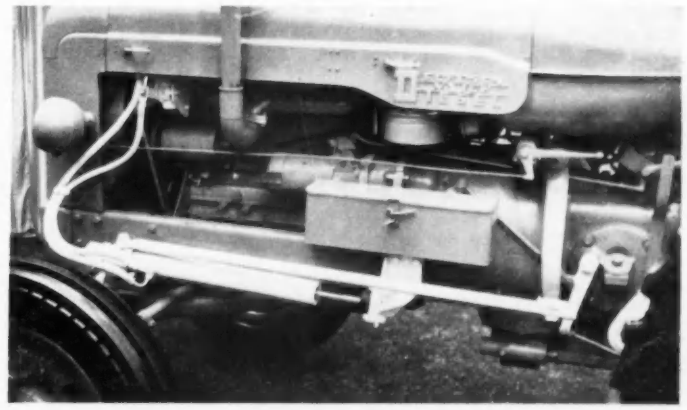


Fig. 1 The hydraulic cylinder giving power assistance to the steering is mounted on one side of the tractor.

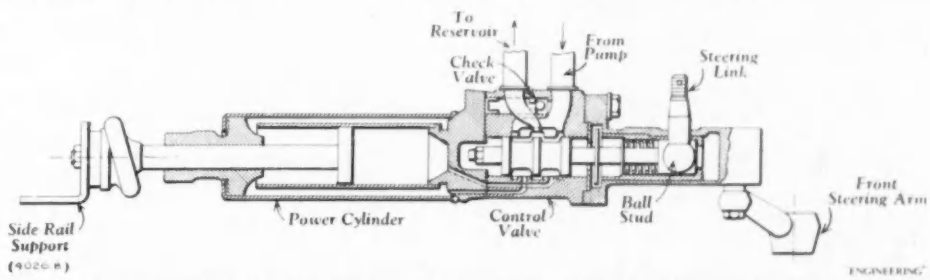


Fig. 2 Movement of the steering wheel moves the shuttle valve which then admits oil to one side of the power cylinder. The valve is shown in the neutral position.

ATOMIC REVIEW

East and West

Potential markets—Contract for Japanese power reactor?—Other nuclear developments in Japan—American plans, projects and resources—Cold power—Glandless pumps for heavy water—Bending beams of charged particles—Separating Boron 10—U.K.A.E.A. forms commercial department—Inspecting atomic power stations.

Looking Overseas

The Roman god from whom the month of January takes its name is generally depicted with two faces, one looking into the past, the other towards the future, as if a knowledge of the past year might serve him in the year ahead. There is something to be said for such a view, and a survey of nuclear developments in overseas countries during 1956 may help in assessing potential markets for 1957. We therefore plan to publish from time to time during the next few weeks brief accounts of developments abroad under various national headings, and begin by summarising news from Japan. That Britain is becoming increasingly interested in fostering atomic progress overseas is confirmed by the news that Professor W. Murgatroyd, Professor of Nuclear Engineering at Queen Mary College, London University, is at present visiting Peru under the auspices of the British Council and at the invitation of the Peruvian authorities. He is to give a series of lectures on nuclear engineering to scientists and engineers and will stay in Peru about a month. He will also be available for consultation by the Peruvian atomic energy commission which has recently been established. We also conclude in this issue our survey of recent events in the United States (see issues of December 7 and 14, 1956).

JAPAN

Power Reactor

During 1956, there was considerable discussion concerning the possible purchase by Japan of a nuclear power station from Britain or the United States. According to a recent report in the *New York Post*, this contest is likely to be settled in favour of Britain. Senator Gore, who has been a leading protagonist in urging the United States to extend its programme, is said to have stated after visiting Japan: "I found the Japanese authorities on the verge of entering into a contract for the purchase of £25 million reactor from Great Britain." Since the war Japan has had close ties with America, but a decision to place an order in the United Kingdom may follow from the fact that Britain already has a nuclear reactor plant producing power on a large scale, while no corresponding American experience yet exists. Another factor may be the limitation imposed by the United States authorities with regard to the release of classified information. Mr. Matsutaro Shoriki was reported in July as saying that Japan would be glad to buy nuclear power stations from America when security and fuel requirements had been relaxed and when the economics of United States reactor systems had been proved. He also said that Britain was well ahead of the United States in nuclear power development. The fuel position has certainly improved since that statement was made and in any case it appears that the Japanese found little to choose between Britain and the United States with respect to uranium supplies, but they were naturally unwilling to risk undertaking an untried reactor system, particularly if they did not have access to all the relevant information.

Earlier this year, when Japan was first considering the purchase of a gas-cooled graphite-moderated reactor based on the Calder Hall design, the question of fuel processing arose. Japan understood that plutonium produced in Japanese reactors would be retained in that country, whereas existing United Kingdom agreements required that all fuel supplied by Britain should be returned for reprocessing. However, Japan has at present no fuel-processing facilities so as yet there can be no conflict. In any case a 100 MW reactor with a 400 MW heat rating and an efficiency of 25 per cent. operating at 80 per cent. load factor would only produce about 90 kg. of plutonium a year.

Britain's case on behalf of the gas-cooled reactor system was put by Sir Christopher Hinton during his visit to Japan last May when he delivered a series of lectures. He is believed to have suggested that a 60 MW station might be initially suitable for Japan and that a gas-cooled plant could produce power at 10 mills per kWh, excluding plutonium credits. (Recent Japanese statements indicate that 10 to 12 mill power would be competitive in Japan if allowance is made for inflation.) Subsequently, Mr. Shoriki announced that a delegation would visit Britain before the end of the year to negotiate the purchase of a 100 MW power reactor to cost about £15 million and be built in 3½ to 4 years. Later, it was reported that the Japanese had revised their plans and were considering a 10 MW plant, though this may well have been an additional project. Mr. Marvin Fox, chairman of the Brookhaven National Laboratory's reactor department, with several colleagues, also visited Japan where questions on American reactor progress were put to him. He advocated waiting until experience of a wider range of systems was available. Japanese atomic engineers have also visited the United States.

In November, a Japanese delegation led by Mr. Ichiro Ishikawa visited this country to investigate the possibility of purchasing a 45 MW or 100 MW gas-cooled power reactor, and it appears that their conclusions have led to a decision in favour of the latter. One consideration which is understood to have weighed against an American advanced reactor system using enriched fuel was that of safety—an important factor in a country subject to earthquakes.

Other Reactor Plants

Japan is also planning to build a number of smaller reactors, including several for research; a total of about eight reactors are envisaged in the current 15 year plan. A boiling-water reactor of about 50 kW, to be installed by Atomics International, a division of North American Aviation, is already under construction in America prior to dispatch, and an agreement to lease fuel for its use has recently been signed between Japan and the United States. The fuel will contain 2 kg. of uranium 235 at 20 per cent. enrichment. The reactor is to be installed at a new nuclear research centre being constructed at Tokai-Mura, 75 miles north-east of Tokyo, for the Japanese Atomic Energy Research Institute. It has also been reported that a licence has been issued by the U.S.A.E.C. for the export of a 50 kW homogeneous research reactor to Japan for use by the Institute. In addition, A.M.F. Atomics have announced that they have been awarded a contract to build a 10 MW heavy-water research reactor for Japan in conjunction with the Mitsubishi group of Tokyo. Inquiries have also been made with British firms for the purchase of a swimming-pool research reactor, but problems with regard to the supply of enriched fuel are anticipated.

In addition, it has been revealed that a United States company—thought to be General Electric—has offered to build a 20 MW boiling-water reactor producing power at 7 to 9 mills per kWh for 6 million dols. (£2 million). The use of nuclear power for marine propulsion is also under consideration in Japan and Osaka Shosen Kaisha have submitted a five year plan for the construction of a vessel with a 20,000 h.p. nuclear plant to the Japanese atomic energy commission. The vessel, it is reported, would be of 20,000 tons and have a speed of 25 knots.

Electronics, Particles and Uranium

The Japanese Ministry of International Trade and Industry is said to be planning a programme for developing the country's electronics industry. With this in view an electronics department is to be formed in the Ministry's heavy industries bureau and a research institute established.

The High Voltage Engineering Corporation, of Cambridge, Mass., U.S.A., are to build a 2 million volt Van de Graaff accelerator for the Japanese Atomic Energy Research Institute. The machine will be equipped for a variety of studies related to the nuclear field. Special targets to be provided will enable the machine to produce X-rays and neutrons, in addition to positive ions and electrons. A beryllium target, when used with positive charged particles to produce neutrons, makes the machine suitable for studies with sub-critical reactor assemblies as well as in activation analysis. For basic nuclear physics studies, a mass stabilising system is to be included which, when used with positive ions, gives an intense beam of monatomic particles with high energy stability.

The Japanese Government Technology Board has announced that high-purity uranium has been produced by an electrolytic process at a cost of about £2 per kg.

Plans

Japan's growing need for electricity is said to be such that some 450 MW of nuclear power will be required by 1965 and 2,800 MW by 1970. Her current appropriation for nuclear energy development is £3·6 million and the Japanese Atomic Energy Commission is to ask for this to be raised to £12 million for 1957. Japan has a number of nuclear research institutes (fundamental physics, radiochemistry, meteorology and laboratories attached to universities) and it is probable that her aim is eventually to become largely self-supporting in the nuclear field.

U.S.A.

Power Plans

In a recent address before the American Nuclear Society, Mr. Lewis L. Strauss, chairman of the U.S.A.E.C., proposed that the United States should build five power reactors in addition to the 18 already projected by mid-1962. They would be of novel design and would serve to "accelerate progress in the development of the optimum power reactors of the future." He said that he would recommend the adoption of a new eight-point expansion programme designed to assure the construction by not later than June 30, 1962, of at least two additional large-scale and three small-scale power reactors. If industry was not prepared to undertake these projects the A.E.C. would do so. Priority would be given to reactors fuelled with natural uranium moderated by heavy water, though small-scale

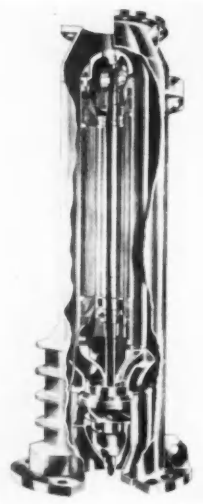


Fig. 1 Sectional view of Hayward Tyler pump as used in the materials testing reactor DIDO for pumping heavy water.

plants of various designs would be considered. In examining the proposals, the Commission would give priority to three particular types of reactors, in this order: first, a large-scale reactor fuelled with natural uranium and using heavy water as its moderator, such a reactor to be of not less than 100 MW electrical capacity; secondly, a large-scale, fluid-fuel reactor system based on aqueous solutions and/or slurries, of uranium and/or thorium-bearing materials, this reactor also to be of at least 100 MW capacity; and thirdly, three small-scale reactor projects of varying new designs.

According to a report published by the U.S. Atomic Industrial Forum, the American atomic energy industry started building or received contracts for 59 nuclear reactors during 1956. Of these, 29 were power reactors and 30 research reactors.

Expenditure

The U.S. Atomic Energy Commission reported last month that its operations during the fiscal year ended last June 30 cost 1,600 million dols. The largest proportion (729 million dols.) of the total was for production of special nuclear materials. The A.E.C. also spent 281 million dols. on source materials; 177 million dols. in reactor development; 59 million dols. in administrative and miscellaneous functions; 51 million dols. in research in chemistry, physics and metallurgy; and 30 million dols. on research in cancer, medicine and biology. The financial report said the Commission had 6,713,000 dols. invested in plant, of which 81 per cent. was in production facilities, 11·5 per cent. in research facilities, and the balance in other installations. The total cost of operations—1,600 million dols.—was more than 300 million dols. greater than the cost of 1955 operations.

Chugach Reactor

The sodium-heavy-water reactor to be built by the Nuclear Development Corporation of America for the Chugach Electric Association, and previously discussed in ENGINEERING, is to have a critical mass of about 150 kg. of uranium 235 with an enrichment of 1·5 per cent. Fuel elements will be arranged in 40 grouped sub-assemblies, each containing 7 rods. The anticipated burn-up is 5,000 MWD per ton; to achieve this life an initial excess reactivity of about 10 to 15 per cent. is necessary, giving a core life of 14 to 23 months at 80 per cent. load factor.

Boiling Reactor Facility

The Atomic Energy Commission will construct and operate an experimental reactor facility which will be used to supplement current work in the boiling water reactor programme. It will be located at the National Reactor Testing Station in Idaho. The experimental facility will consist of a reactor core and pressure vessel, steam condensers, heat exchangers, pumps and the necessary valves, controls and auxiliary equipment. It will have sufficient flexibility in size, power removal equipment, and design pressure to simulate experimentally a wide range of operating conditions pertinent to the performance of boiling water reactors. The facility, to be known as the Argonne Boiling Reactor Facility (ARBOR), will be operated by the Argonne National Laboratory, Lemont, Illinois, as an extension of the work on boiling water reactors currently being conducted by the laboratory. This work includes the so-called BORAX (Boiling Reactor) experiments and fabrication and operation of EBWR (Experimental Boiling Water Reactor). The reactor is expected to cost 8½ million dols. and is likely to begin operation late in 1959.

Reactor Concept

A new reactor concept, said to be simple, flexible and entirely safe, is being developed by the General Atomic Division of General Dynamics. It is a homogeneous solid fuel reactor (fuel and moderator homogeneous but coolant external) and would have a core comprising a solid mixture of partly enriched uranium and some light material such as beryllium. The safety of this system would arise both from the "warm neutron effect," which could in favourable circumstances yield large negative temperature coefficients, and from Döppler broadening of the uranium 235 resonances as the core temperature increases. It is notable that the very high temperature (VHT) reactor described at the recent B.N.E.C. symposium might similarly be described as homogeneous since its ceramic fuel would be dispersed in the graphite moderator.

Propulsion

In our issue of August 24 (page 252) we discussed the steps being taken to advance the date at which nuclear reactors will be used to provide power for the propulsion of ships, aircraft and locomotives. Some further news on the subject has accumulated since then. President Eisenhower has directed the A.E.C. and the Department of Commerce to proceed with the construction of an atomic powered merchant ship which will be a dual-purpose 21 knot vessel carrying 100 passengers and 12,000 tons of cargo. The propulsion plant will employ a pressurised-water reactor and will develop 20,000 h.p. The A.E.C. has accepted as a basis for contract negotiations a proposal by the Babcock and Wilcox Company of New York to design, construct and test a propulsion plant for this purpose. The project is to be completed in 39 months. The Foster Wheeler Corporation of New York, the General Electric Company of Schenectady and the Ingalls Shipbuilding Corporation of Birmingham, Alabama, are also concerned with work in this field.

In addition, it is understood that four studies of advanced ship propulsion units have been undertaken by AMF Atomics, Atomics International, the Ford Instrument Company (a division of the Sperry Rand Corporation), and General Motors for the U.S. Maritime Administration. These firms are engaged on a feasibility study for a gas-cooled nuclear propulsion plant, to be used in a closed-cycle gas turbine system. The plant is for a proposed "707 ft. long super-tanker with a capacity of 38,000 tons dead weight," to be completed by 1961. The reactor, fuelled with slightly enriched uranium, would heat the gas to approximately 1,300 deg. F. (700 deg. C.), and it is intended that the design shall give high cycle efficiency at both full and part load. The use of the closed cycle will permit control of power output without changing the reactor gas outlet temperature by bleeding gas from the system. Flexibility of control might be achieved by use of a cooled turbine by-pass loop.

Other propulsion news includes a U.S. Navy contract awarded to the Bethlehem Steel Corporation to build a 700 ft. nuclear powered guided missile cruiser with a displacement of 14,000 tons. The reactor plant is to be the responsibility of the Westinghouse Electric Corporation. The construction of an 85,000 ton 33 knot aircraft carrier with eight nuclear powered engines is also to begin next year. Serious technical difficulties may compel the U.S. Navy to replace the sodium-cooled reactor unit of the submarine Sea Wolf with a pressurised-water reactor. Sodium is, of course, a chemically dangerous substance and highly corrosive, and it was reported earlier that leaks had developed during dockside testing. The Westinghouse Electric Corporation have received a large contract for the construction of reactors for submarines. In *Jane's Fighting Ships* (1956-57) it is stated that, following the success of the Nautilus, all submarines built for the United States Navy in future will have nuclear propulsion units, and United States Naval authorities anticipate that by the 1960's all projected ships will be atomic powered. There are at present four large (approx. 3,000 tons) nuclear powered submarines (Nautilus, Sea Wolf, Skate and Swordfish) completed or building, and six more ordered; three medium-size (approx. 2,500 tons) submarines (Sargo, Seadragon and Skipjack); one very large (approx. 5,500 tons) submarine with two reactors (Triton) and one guided-missile submarine (approx. 2,900 tons), making 15 nuclear powered submarines in all.

Three American firms are co-operating on the development of atomic powered locomotives. These are the Baldwin-Lima-Hamilton Corporation, the Denver and Rio Grande Western Railroad and the Walter Kidde Nuclear Laboratories.

Fuel

In November President Eisenhower approved the decision to make available 20,000 kg. of uranium 235 for distribution abroad. This is in addition to the 5,000 kg. set aside for the initial operation of the International Atomic Energy Agency. Prices will be identical with those charged by the A.E.C. under the United States

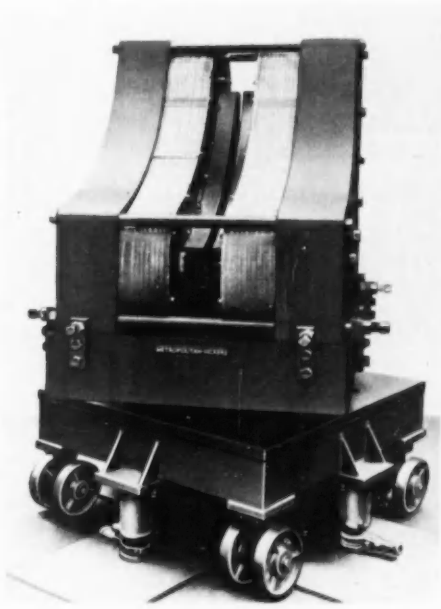


Fig. 2 Magnet for deflecting a beam of charged particles emerging from an electrostatic generator. It has been made by the Metropolitan-Vickers Electrical Co. Ltd., for the Atomic Weapons Research Establishment, Aldermaston.

domestic programme. The charge for uranium with 20 per cent. enrichment in uranium 235 will be 16 dols. per gm., for 0·72 per cent. enrichment 5·62 dols. per gm., and for 90 per cent. enrichment 17·07 dols. per gm. The charges of 40 dols. per kg. for natural uranium metal and 28 dols. per lb. for heavy water remain unchanged. Arrangements have also been made to buy back plutonium and uranium 233 produced in reactors abroad fuelled under co-operative agreements. For plutonium metal the price is 12 dols. per gm. and for uranium 233 nitrate 15 dols. per gm. of uranium 233.

The Bureau of Mines of the U.S. Department of the Interior have published a 130 page handbook entitled *Facts Concerning Uranium Exploration and Production*. It is available at 70 cents per copy from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

Last month the U.S.A.E.C. announced that the United States produced 3,750,000 tons of uranium ore in the past 18 months. The Commission also stated that the production of uranium oxide is now running at the rate of 8,000 tons a year—double that of last year—and that the estimated United States reserves of uranium ore amounted to 60 million tons. Uranium concentrate production from July to December, were 3,400 tons of uranium oxide (U_3O_8), as against 1,600 tons for the corresponding period in 1955. The A.E.C. report that there are 12 uranium mills operating in the United States, with eight more under construction. A plant at Monticello,

Utah, is owned by the A.E.C. and 11 are privately owned.

The Canadian Institute of Mining and Metallurgy was told by Mr. F. R. Joubin that Canada will be the world's largest uranium producer by mid-1957. He said that the United States and Latin America would tie for second place, the Belgian Congo would be third and Australia fourth. Canadian reserves of uranium ore are said to be about 225 million tons—enough to supply Britain's electricity needs for 400 years.

Power from the Cold

A recent issue of the U.S. Information Service *Atoms for Peace Digest* reports that the United States is starting research on a theory that "super-atomic" energy can be released by applying extreme cold to atoms. The theory, evolved by Mr. Robert L. Carroll, a U.S. Navy scientist, challenges the views that —273 deg. C. is the lowest temperature possible and that 186,000 miles per second is the maximum speed attainable by light. Mr. Carroll believes that as an atom becomes colder and less acitve, its electrons gravitate towards the nucleus, or its centre, and are forced to move increasingly faster. Once the atom becomes cold enough, the electrons will plunge into the nucleus, thus disintegrating it, and releasing its entire energy.

HOME NEWS

Glandless Pumps for DIDO

The DIDO reactor is cooled and moderated by heavy water which enters the base of the calandria through three 9 in. pipes closely grouped at the centre. From the plenum chamber the heavy water rises through the fuel element boxes and then out through radial openings into the tank. Four 7 in. bell-mouth weir pipes are fitted in the base of the tank, and the hot heavy water flows down these to a header in the plant room and so through a battery of three heavy water pumps to three heat exchangers. These pumps, which maintain the circulation of heavy water through the reactor, are of the glandless type, powered by wet motors, and manufactured by Hayward Tyler and Company, Limited. Each unit comprises a single-stage centrifugal pump direct-coupled to a 60 h.p. 1,460 r.p.m. 415 volt 3 phase motor. Both pump and motor are enclosed in a stainless-steel shell which completely eliminates leakage. The materials of constructions are stainless steel and aluminium, and both thrust and journal bearings are of the tilting-pad type employing stainless-steel pads with plastic thrust-disc and journal sleeves. In order to exclude all contamination, the pumps were assembled under conditions of surgical cleanliness. A sectional view of a Hayward Tyler heavy-water pump is illustrated in Fig. 1.

Beam Bending Magnets and Spectrometry

Two sets of beam-bending magnets have been built by Metropolitan-Vickers Electrical Company, Limited, for the Atomic Weapons Research Establishment at Aldermaston. Each set includes a large trolley-mounted electromagnet, as illustrated in Fig. 2. This magnet is used to deflect the vertical beam of charged particles emerging from an electrostatic generator through 90 deg. into the horizontal direction, where it is then directed by a smaller magnet on to one of three target areas. Two such installations have been made on successive floors of a building. Apertures have been left in the baseplates of the magnet and also in the floor so as to allow an undeflected beam to pass through to the floor below where it can then be deflected in a similar manner by the second set of magnets. Each large magnet provides a flux density of 12,500 gauss in a 1 in. air gap between kidney-shaped pole pieces, the surface area of which is approximately 150 sq. in. The energising coils are wound from hollow aluminium conductors, through which cooling water is circulated at a rate of 2 gal. per min. The electrical input is of the order of 6½ kW, and the weight approximately 5¼ tons. The small magnets provide a flux density of 12,500 gauss in a 1 in. air gap between wedge-shaped pole pieces and are also water cooled. Both large and small magnets have adjustable pole pieces, which allow variation of the angles of entrance and exit of the beam relative to the boundary of the magnetic field.

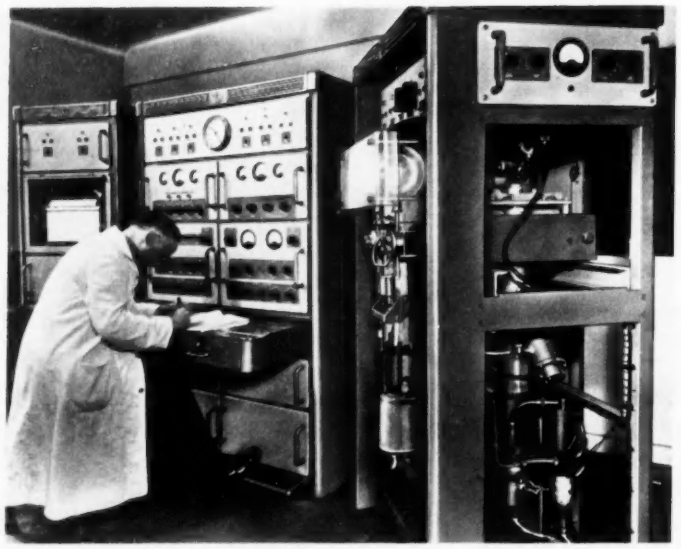


Fig. 3 Metropolitan-Vickers mass spectrometer, MS2, in use at Harwell for routine isotopic abundance measurements and gas analysis.

Other Metropolitan-Vickers equipment employed by the U.K.A.E.A. includes that company's MS2 spectrometer, which is shown in Fig. 3 in use at the Atomic Energy Research Establishment, Harwell, for routine isotopic abundance measurements and gas analysis.

Commercial Department for U.K.A.E.A.

The United Kingdom Atomic Energy Authority have set up a Commercial Department within their Industrial Group, to handle sales of uranium, plutonium, thorium, graphite and other similar materials for the Authority. Within the general policies laid down by the Authority, this department will be responsible for negotiating terms and conditions of sale, including the determination of selling prices. The current price of uranium is £10,000 a ton, and of plutonium £12 a gram. The manager of this department is Mr. W. P. Warren, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, Near Warrington, Lancashire. Radioisotopes, stable isotopes, and special requirements for small quantities of research materials, will continue to be handled by the Research Group of the Atomic Energy Authority.

Isotope Separation Plant

A boron 10 separation column is now in production at the premises of Twentieth Century Electronics Limited, New Addington, Surrey. The column, which is 30 ft. high, is a narrow tube containing some 5 miles of stainless steel wire and is suspended in a vacuum vessel to minimise heat losses. The raw material is distilled at the foot, and the product passed through the tube until it condenses as a colourless liquid; the tube is at a series of different temperatures throughout its length. The liquid is removed at the rate of a droplet every few minutes, and the total output is about a pint a month. After further chemical processes in which the liquid is purified, it is stored in glass containers in the form of boron-trifluoride etherate. This product is mainly used for filling the company's boron-trifluoride neutron counters, but it also has other applications, in medicine and nuclear research, for example. The boron 10 is said to have an enrichment of over 99 per cent.

Inspection of Nuclear Power Plant

Lloyd's Register of Shipping (Land Division), which was entrusted with inspection during construction of the Calder Hall Atomic Power Station on behalf of the United Kingdom Atomic Energy Authority, is to provide similar services for the Atomic Power Stations which are to be built for the Central Electricity Authority.

★ ★ ★

UNIT CONSTRUCTION OF POWER PRESSES

Among the new machines introduced by E. W. Bliss (England), Limited, City-road, Derby, is a range of enclosed type, geared eccentric presses, based on the unit system of construction. The presses are available in various tonnages as both single-geared and double-geared models, the basic design being the same in all cases. A fabricated steel four-piece frame houses the main working parts of the press, and carries a quill-mounted flywheel and overhung clutch built as a unit with a gear-case carrying the main driving motor. Nothing is built into the crown of the press except the main gears, and as a result the complete driving gear can be removed from the press as a unit. This ease of removal and replacement applies also to the components of the drive; the quill assembly and clutch can be taken out of the gearcase after removing six screws, and belts can be replaced without removing anything but the brake pins. To the basic press can be added a number of extra features, and the result is a flexible design which can be made to meet a range of different requirements by the addition of extra features.

★ ★ ★

SPECIAL-PURPOSE GREASES

A range of greases to be known as Molytone is now being put on the market by Rocol Limited, Ibex House, Minories, London, E.C.3. They are based on the Bentone range of greases which contain molybdenum disulphide. There are four in the new series: the "Grease" having a working temperature up to 450 deg. F. and a working pressure up to 100,000 lb. per sq. in.; "L.M.," which is designed for lubrication of gas cocks, plugs and valves, particularly in warm situations; "X," which is for use as a rubber lubricant, and is both petroleum resisting and water repellant; and "C," which is a modification of "X" to give a softer form for specific use in car brake servos. It should be noted that Bentone greases do not use a metallic soap, but a modified Bentonite clay as the thickening agent. As a result they are heat stable and have no melting point, so that they can be used up to the point of inflammability.

★ ★ ★

In our issue of November 30, 1956, page 686, we attributed some experiments on effusion cooled turbine nozzles to members of D.S.I.R. The work was actually performed by Mr. S. J. Andrews, Mr. H. Ogden and Miss J. Marshall of the National Gas Turbine Establishment, Pyestock. The material from which the article was drawn was an Aeronautical Research Council issue of a National Gas Turbine Establishment report, registered as current paper No. 267.

In Parliament

LACK OF STEEL FOR SHIPS

Difficulties regarding shortages in the supply of steel continue to be raised. In one of the last sitting days before the Christmas recess, Mr. S. S. Awbery (Labour) asked if the Parliamentary Secretary to the Admiralty was aware that " for the first time in their history " shipowners in the United Kingdom had been compelled to have a large amount of tonnage constructed abroad because berths were not available in this country. Mr. Hector Hughes (Labour) asked for a further statement on the supplies of steel to Scottish and British shipyards, respectively, indicating the allocations to each and the steps being taken to increase the supplies to the Scottish shipyards.

On these points, Mr. S. Wingfield Digby, the Civil Lord of the Admiralty, said that the increased demand for ships was principally for oil tankers, the building of which was taxing the resources of shipyards in this country and abroad. In these circumstances, it was hardly a matter for surprise that some orders by British shipowners had gone abroad. The provision of additional building berths in this country would create no solution to the problem until more steel plates and sections were available. Moreover, if many more berths were built, a shortage of skilled manpower would arise. The First Lord of the Admiralty, Viscount Hailsham, was doing what he could to encourage the supply of more steel for shipbuilding, such as would enable a greater output of shipping to be achieved and thereby encourage the further development of British shipyards.

There was at present no Government system in force for the allocation of steel to shipyards and firms were free to order their supplies where they could. Scottish shipyards, like all other shipyards in the United Kingdom, were receiving more steel than last year, but supplies continued to be considerably below the requirements of the shipbuilding industry. The First Lord of the Admiralty and the President of the Board of Trade were consulting with the various industries concerned to secure further improvements in the situation.

SHIP-REPAIRING FACILITIES

Concern was expressed by Mr. Paul Williams (Conservative) regarding the dockyard and repair facilities for large ships in the United Kingdom. He asked the Parliamentary Secretary to the Admiralty whether he was satisfied with the existing arrangements and what steps were being taken to improve the position.

Mr. Wingfield Digby said that he had good grounds for believing that the ship-repairing industry was fully aware of the importance of providing for the docking and repairing of the larger ships which were now being built or which were on order. The repair facilities already available, together with the additional facilities under construction or planned, should be sufficient for large vessels for the next few years. After that, the need for large dry docks was expected to increase. Encouragement was being given by the Admiralty to the expansion of repair facilities for these ships. Finance Acts in recent years had provided added taxation relief on the capital costs of building dry docks.

TRANSFERS TO FOREIGN FLAGS

Particulars regarding the transfer of British ships to registrations overseas were sought by Mr. Awbery. He asked Mr. Harold Watkinson, the Minister of Transport and Civil Aviation, how many ships registered in United Kingdom ports had been transferred during the past two years to flags of convenience, such as the Panamanian, Liberian, Costa Rican, and Bermudian, and to what extent the ownership of the vessels concerned had changed in accordance with the change of flag.

Mr. Watkinson said that 74 ships, of 500 gross tons and over, were transferred from United Kingdom registry to registry in Panama, Liberia or Costa Rica, during 1954 and 1955, and that a further 36 ships had been so transferred during the first eleven months of 1956. Three ships were transferred from United Kingdom registry to registry in Bermuda during 1955 and 1956, and these remained British ships flying the British flag. No ship had been transferred to registry in Bermuda during the first eleven months of 1956. In all these transfers, Mr. Watkinson pointed out, the legal ownership of the vessels concerned had been changed.

BRITAIN'S NEED OF TANKERS

Problems concerning the use of British oil tankers for the conveyance of oil from the Middle East to the United States were raised by Mr. Victor Collins (Labour). He pressed the Minister of Transport to take steps to ensure that the vessels were used, during the present emergency, for the shipment of oil to the United Kingdom. Mr. Frederick Lee (Labour) wanted the Minister to seek agreement with other West European powers, or countries interested in the North Atlantic Treaty Organisation, for the creation of an international fleet of oil tankers appropriate to their future requirements.

Dealing with these aspects of the shipping situation, Mr. Watkinson said that very few British tankers were being used for the transportation of oil from the Middle East to the United States. The appropriate international authorities were, in fact, urgently considering whether it would be of advantage to transfer the vessels being used on these and other routes. Future requirements of oil tankers were at present being studied by the Government in consultation with the oil industry. The international nature of this problem would certainly call for close consultations between the British and other interested Governments, both inside and outside Europe. He also told Mr. Lee that it was the policy of the Government to encourage investment in large, fast tankers, suitable for the Cape route, as well as in the smaller types of these vessels capable of passing through the Suez Canal. Both types were equally essential for the world-wide movement of oil.

EMBRYO ENGINEERS

A number of questions regarding the encouraging of young people to take up the study of engineering and science were put to Sir David Eccles, the Minister of Education, by Mr. Ellis Smith (Labour). He asked the Minister if he were satisfied that the existing secondary-education facilities and the selection of children at the age of 11-plus were providing the required increases in the numbers of students who might be suitable to meet the increasing needs of industry. Mr. Smith also wished to know what action the Minister intended to take in order to provide for the requirements of engineering, technology and science during the next ten years, and if the Minister would call together the directors of education of all large industrial concerns, so that arrangements might be made for the works educational facilities, when not in use, to provide the foundation for a co-operative educational programme to meet the growing needs of industry.

What action, Mr. Smith inquired, had the Minister taken to encourage girls to study for engineering and science, and what special attention had been given to paragraphs 87 to 92, on further education for girls, in the White Paper on *Technical Education* (H.M.S.O. Cmd. 9703) ?

Sir David said that he could not describe the Government's policy for education in answer to a parliamentary question, but he could assure Members that Her Majesty's Ministers had the needs of industry constantly in mind. If Mr. Smith could tell him of any spare capacity in any works' schools, he would be much obliged for the information. As to the paragraphs in the White Paper, these had already received wide publicity. There was, in fact, encouraging evidence that the advantages of further education for girls were becoming better appreciated. The Minister agreed that a knowledge of geometry and other branches of mathematics was the basis for meeting the country's present industrial needs. He felt that industry could do a great deal in the direction of making girls interested in engineering. Head mistresses and girls at school should be made aware of the kind of employment which was open to girls who took mathematical subjects.

Actually, the number of girls who had obtained passes at advanced level, at the General Certificate in Education examinations, in mathematics and science had increased by 40 per cent. in the last five years. Industry generally was doing a great deal in the matter of education, but, said Sir David, industry and the Minister together had still a long way to go.

Uranium and Thorium Supplies

A request for information regarding any surveys that might be made in the colonies for uranium and thorium was made by Mr. Hector Hughes (Labour). Mr. Alan Lennox-Boyd, the Secretary of State for the Colonies, replied that special surveys had been made in eleven British colonial territories. These had not, as yet, disclosed any major deposits of uranium capable of economic working. Thorium, however, was being mined in both Nigeria and Malaya.

Nuclear Power Production

In reply to Mr. Emrys Hughes (Labour), who asked to what extent the production of electricity would be augmented by the new atomic power station to be erected in Ayrshire, Mr. James Stuart, the Secretary of State for Scotland, said that the station planned by the South of Scotland Electricity Board, if approved, would provide some 2,000 million units of electricity annually.

Inter-European Trade

Interest in the progress being made towards the establishment of the European common market continues to be shown by members of both Houses. Mr. A. Fell (Conservative) asked the Secretary of State for Foreign Affairs what discussions had taken place on this subject during the recent meetings in Paris of the North Atlantic Treaty Organisation. In reply, Mr. Selwyn Lloyd said that he and Mr. Harold Macmillan, the Chancellor of the Exchequer, had had useful discussions with Monsieur Spaak and other ministers.

Pneumoconiosis in Foundries

The spread of pneumoconiosis among foundry employees was raised by Mr. J. Dugdale (Labour). Mr. John Boyd-Carpenter, the Minister of Pensions and National Insurance, told him that 50 claims in respect of the occurrence of this disease among foundry operatives were being dealt with at the West Bromwich office of the Ministry. Of the 207 foundry workers receiving pensions for pneumoconiosis in West Bromwich, it was estimated that more than half of them were receiving a special hardship allowance in addition, on account of a change of occupation. It was not known how many of these men had left the foundry industry.

Admiralty's Material Organisation

Questions regarding the pay and conditions of service of officers in the Ordnance Inspection Department at the Admiralty were raised by Commander J. F. W. Maitland, R.N. (retd.) (Conservative) and Sir Ian Clark Hutchison (Conservative). On this matter, Mr. Wingfield Digby said that the Naval Ordnance Design and Inspection Pool was included in the inquiry now being conducted into the material organisation of the Admiralty by the committee under the chairmanship of Sir Barclay Nihill, K.B.E. It was inexpedient and undesirable, therefore, that the future of the Pool should be considered outside the context of that committee's overall review. An interim upward adjustment of the Pool salaries was being considered separately and, Mr. Digby said, he hoped that an improvement in pay would be introduced very shortly.

THE HUMAN ELEMENT

An industry looks ahead—Group working can be popular—The right to live and work—Resettlement is a public relations job—The lure of America—Migrants misled.

★ ★ ★

Scholarships in Cotton

Sir Raymond Streat, the chairman of the Cotton Board, announced at Blackburn just before Christmas that a big drive is to be undertaken by the cotton textile industry to tell school leavers about new scholarships which are to be available for those who wish to study science and technology with a view to a career in the cotton industry. Scholarships are being sponsored by cotton concerns and by trade associations within the industry, and many of them will be tenable at the Manchester College of Science and Technology.

The move is particularly welcome in cotton. Even the Socialist planners in their day shrank from writing off the Lancashire cotton industry and, indeed, gave it half-hearted encouragement in the Cripps capital equipment scheme. The industry is therefore to be saved and there is no time to lose in taking constructive steps to that end. One of the difficulties under which the industry has laboured for some time now is a lack of first-class men. There is plenty of ability left in Lancashire in the progressive concerns, but there are a large number of owners who are tinged with the philosophy of "après nous le déluge." This attitude encourages neither the technical people who are there nor those who might make their career in cotton textiles.

Beyond the question of scholarships and other schemes to foster a compact, highly capitalised industry lies the question of salaries. If cotton is to have good new material which will work for technical qualifications it must also be prepared to pay salaries at the market rate.

★ ★ ★

Attitude to Work

Social surveys are repeatedly showing up the importance which factory workers attach to their working conditions. This seems to loom much larger in an era of full employment than might have been supposed. The latest evidence of this pre-occupation comes from a report put out by the Medical Research Council called "A Study of Attitudes to Factory Work" (H.M.S.O., price 10*s*.). The study was based on an investigation in three large mass-production factories in England. Two of them were car plants and the third a group of metal-rolling factories. In other words, the basic condition set by the study was that work would be repetitive and probably not of great intrinsic interest. This fact is important for it suggests that if the survey had been primarily concerned with skilled men (in the widest sense of the word) it might have shown that men who concentrate on the job for reasons of interest would be less concerned about their environment.

Most men in the survey were satisfied with their job. A surprisingly high proportion found the work interesting and there was a marked tendency for satisfaction to increase with age. Clearly security and habit play an important part here and the dissatisfied ones will tend to move on when still young. Most satisfaction was found among those working in small groups. Men were found to value the social element in such working arrangements. It was found that most of the men were on some form of group payment, usually of an incentive nature, and there would seem to be a significant correlation between group organisation and satisfaction. The study is indeed a vindication for those who emphasise the importance of group organisation in some form in the factory and also for those who argue that incentive payments are sound where groups are small, where the system of payment is simple, where the operational cycle is both short and repetitive and where anomalies do not exist between groups.

★ ★ ★

Expelled Union Member

The West Hartlepool engineering operative who sued local officers of the A.E.U. for damages, conspiracy and wrongful interference with his employment, has won his case. A judge in the Chancery Division has awarded him £500 damages and part of the costs. The plaintiff alleged that he had been "sent to Coventry" by his work mates for refusing to join a token strike in December, 1953. The judge found that there had been a conspiracy against the union member and that in an area where there was nearly a 100 per cent. closed shop, expulsion from the union meant a gross interference with an individual's ability to earn a living.

Reading between the lines, it would seem that the sanction used by the union was the final chapter in a long and unhappy relationship between the plaintiff and the union and that, legal issues apart, there were faults on both sides. The case has, however, two issues of principle which raise the matter above the personalities involved. First, it is clear that the union was using an instrument of policy which has frightening implications. It is important that the extent of the power of that tool should be discussed and delineated in a court of law. Second, the defendants argued that their actions were protected by the Trade Disputes Act, 1906. They were therefore claiming that this case was a trade dispute, and it is vital to know if the liberty of the subject can be seriously violated by a powerful organisation declaring such a set of circumstances to be legally covered by a formula of that kind.

The judge considered that the case was not concerned with a trade dispute. In his opinion, the defendants were not furthering a trade dispute but a grudge. He would not grant an injunction but gave leave to the plaintiff to move for one if further victimisation required it. He hoped that wiser counsels would prevail. There the law can leave it, but the human relations problem for the union remains a difficult one.

★ ★ ★

Moving from the Slums

People grow roots, even on infested and poisonous ground. To transplant them is no easy matter and requires great care. The older they are the greater is the danger to them, and to those who plan the move. The need for deep understanding of the human problems involved in re-housing people is underlined in a report by the Housing Management Sub-Committee who were appointed a year ago by the Central Housing Advisory Committee "to examine problems of housing management arising from the re-housing of families from unfit houses, and to make recommendations."

The resumption of slum clearance on a large scale by local authorities, after an interval of 17 years, required a clear statement of the human aspects of such an enterprise. The committee, whose chairman was Professor J. M. Mackintosh, M.D., LL.D., concerned themselves primarily with the families affected by slum clearance proposals. To them slum clearance was "a long-awaited opportunity for attacking once more the wretched conditions which still restrict and darken too many lives." But the element of compulsion in the move from hovels to modern, well-equipped houses is not always welcome. Many of the families concerned have to make a major re-adjustment to their way of living and to their budgets. Rents are higher, the new homes have to be furnished, old social ties and habits are broken, new schools have to be found for the children, travel to work may be increased. The social upheaval the move entails, and the fact that it is enforced, make necessary "a careful study of the needs of individual families" and a search for ways of meeting them.

Local authorities are told that they must employ experienced and well-qualified officers to explain the purpose of the move to the people concerned. Good public relations are an essential pre-requisite of success. The Committee's report is a clear and thoughtful document: the appalling state of affairs it reveals is a matter for the deepest concern of the whole nation.

★ ★ ★

Scientists Go West

About 100 engineers and a similar number of people from other professions, including chemists and physicists, leave the United Kingdom each year for work in the United States. Though the numbers are small, they are known to include a significant proportion of scientists with the highest academic qualifications, particularly those who win a first-class honours degree and go to the United States or Canada on research fellowships. From Oxford alone almost 12 go each year and two or three remain. Although Oxford may be more closely linked with the United States than many other British universities, a loss of about 10 per cent. is not unusual. Whether or not this is likely to become more serious is examined in an article published in *The Financial Times* of December 24.

It was at one time widely believed that one of the attractions of a career in the United States was the absence of military service for immigrants. The Government's decision to exempt first-class honours graduates from military service will therefore, be welcomed though only a few scientists and engineers will be affected (the average British University turns out between 10 and 20 such first-class honours degrees a year). The author concludes that the "lure of the North American continent to scientists and technologists is undoubtedly the pay packet," and points out that an industrial scientist in this country earning £1,000 a year would be paid £2,850 in the United States. Also the salary scales climb much higher in the United States and the incidence of taxation is less.

Another factor, which may exercise a strong influence on the research graduate, is the greater freedom in research allowed in the United States, and the better laboratory equipment generally available. It could also be the higher social status of the American technologist, or that America is the hub of the technical world. On present figures, the drift is not alarming, but an intensified United States recruitment drive could well lead to serious losses.

★ ★ ★

Hungarian Refugees

Not, apparently, all of those Hungarians who were arriving in Britain by special airlift before Christmas expected to stay. The majority of the 15,000 or so who have arrived were under the impression that they would fly on to the United States, Canada or Australia within a few days. That this did not happen led to discontent and distress among the refugees. The publication in *The Times* of a letter by Mr. F. Kellerman pointing this out (December 17) drew an explanatory reply from Mr. Harold H. Tittmann, director of the Inter-Government Committee for European Migration.

It seems that the refugees, before they left Hungary, were given a leaflet issued by the International Committee for European Migration which implied that if they came to Britain they could go within a few days to the United States, Canada or Australia. But the United States have limited the number to be admitted to 21,500 and there is little likelihood of the other two countries being able to accommodate the large numbers who have answered the leaflet's call.

By December 18, 136,901 Hungarians had already crossed into Austria, and some 8,000 were entering each night. About half the total were moved from Austria by December 18, of which less than one quarter came to Britain. Could it be that the authors of the leaflet have miscalculated the effect of their own propaganda?